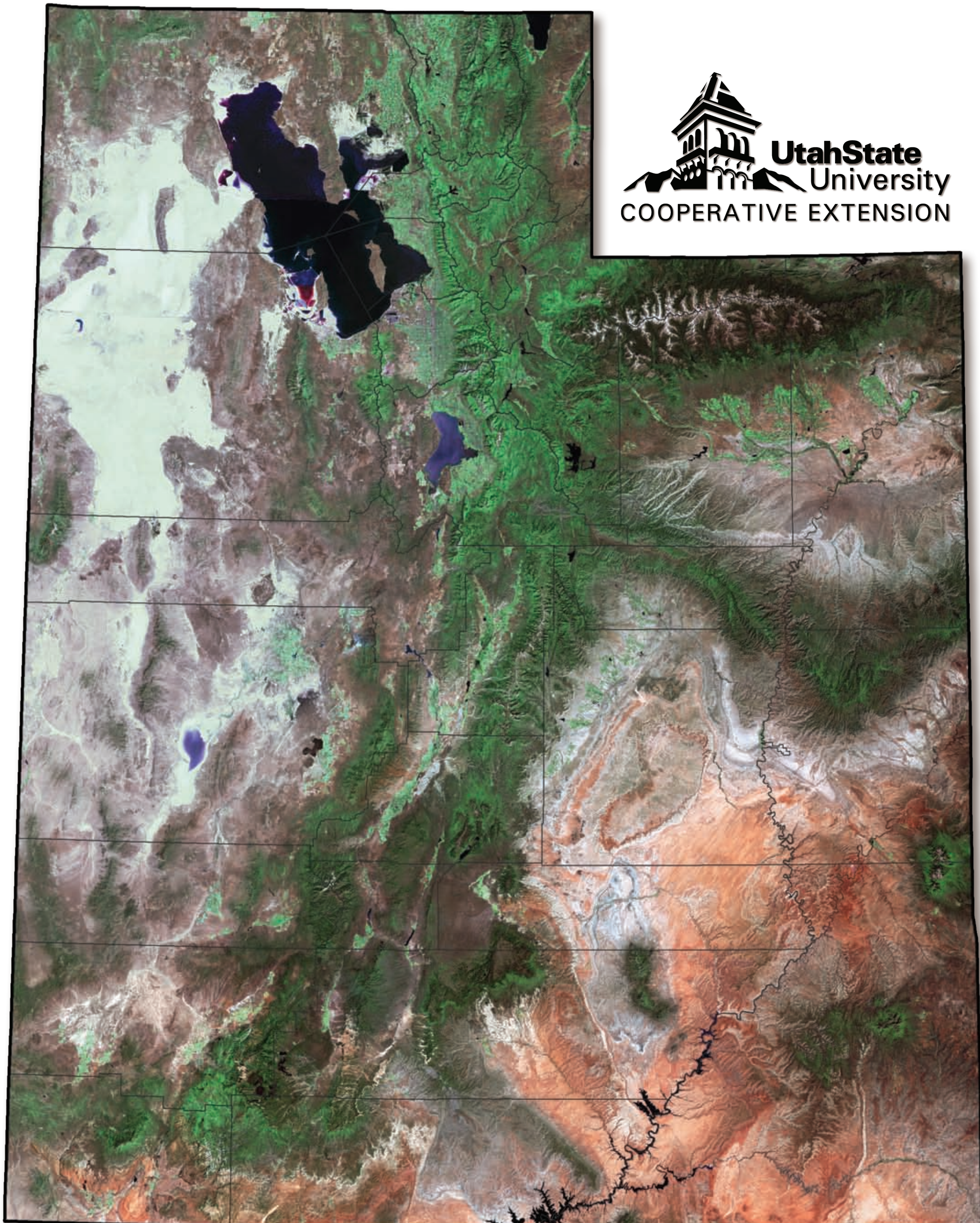
RANGELAND RESOURCES OF UTAH



UtahState University
COOPERATIVE EXTENSION

Utah Public Lands Policy Coordination Office

2009

Front cover image provided by the Remote Sensing/Geographic Information Systems Laboratory at Utah State University
http://www.gis.usu.edu

Photos by Ellie Leydsman McGinty

Utah State University is committed to providing an environment free from harassment and other forms of illegal discrimination based on race, color, religion, sex, national origin, age (40 and older), disability, and veteran's status. USU's policy also prohibits discrimination on the basis of sexual orientation in employment and academic related practices and decisions.

Utah State University employees and students cannot, because of race, color, religion, sex, national origin, age, disability, or veteran's status, refuse to hire; discharge; promote; demote; terminate; discriminate in compensation; or discriminate regarding terms, privileges, or conditions of employment, against any person otherwise qualified. Employees and students also cannot discriminate in the classroom, residence halls, or in on/off campus, USU-sponsored events and activities.

This publication is issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Noelle E. Cockett, Vice President for Extension and Agriculture, Utah State University.

RANGELAND RESOURCES OF UTAH

PROJECT COORDINATORS:

Roger E. Banner

Ben D. Baldwin

Ellie I. Leydsman McGinty

DOCUMENT COMPILED BY:

Ellie I. Leydsman McGinty

Utah State University
Cooperative Extension Service
Logan, Utah

in cooperation with

State of Utah
Governor's Public Lands Policy Coordination Office

2009

State of Utah Control No. 080720
Utah State University Control No. 080300

UtahStateUniversity
COOPERATIVE EXTENSION

ACKNOWLEDGMENTS

This document is a revision of *Rangeland Resources of Utah*, which was published by the Utah State University Cooperative Extension Service in 1989. Although the emphasis of this document is on rangeland resources, it presents a broad overview of the physical, biological, and social features in Utah, as well as detailed information on land ownership, land use, current issues, and discernable trends. This document is intended to be useful in the formulation of natural resource policy and in decision-making for Utah rangelands.

Information for this document was compiled by a team of researchers and professionals at Utah State University from the Cooperative Extension Service, the colleges of Natural Resources and Agriculture, and the Remote Sensing/Geographic Information Systems Laboratory. The project entitled *Setting the Stage for a Livestock Grazing Policy in Utah* was accomplished under the terms of Contract Number 080720 with the State of Utah Public Lands Policy Coordination Office.

Much of the direction and coordination of this publication was carried out by Ellie Leydsman McGinty, a graduate student in the Bioregional Planning Program and research technician at Utah State University. Her outstanding skills in design, cartography, and layout, and her untiring commitment and dedication to producing a high-quality, informative product deserve our highest praise, respect, and gratitude. Special thanks are due to the authors and contributors who provided their expertise in writing the various sections of the revision.

Special thanks and recognition are due to Kendall L. Johnson, the editor and director of the original *Rangeland Resources of Utah*, and to the original authors who contributed to that effort. Appreciation is expressed to Utah State University Cooperative Extension Service for providing the digital home of the 2009 revision of *Rangeland Resources of Utah* on the Utah State University Extension Website. Special thanks is also due to the technical editors in Extension Marketing and Communications, Donna Falkenborg, Julene Reese, and Lisa Woodworth, as well as Tracy Jones in the Department of Environment and Society in the College of Natural Resources.

Last, special thanks are offered to State Senator Dennis E. Stowell, from Senate District 28, and the Public Land Policy Coordination Office for supporting this effort.

Roger E. Banner
Extension Rangeland Specialist and Project Co-Director
Department of Wildland Resources

Ben D. Baldwin
Project Co-Director
Department of Environment and Society

Table of Contents

List of Figures

List of Photographs

Photo credits: Southwest Regional Gap (SWReGAP) Landcover Project

List of Tables

List of Tables in Appendices

About This Document

This document provides an overview of the complex issues occurring on Utah rangelands. State Senator Dennis E. Stowell (District 28) was the initial impetus for this effort based on his desire to have important information and data about rangelands available in one location. The Public Land Policy Coordination Office (PLPCO) supported these efforts and has provided additional focus and direction.

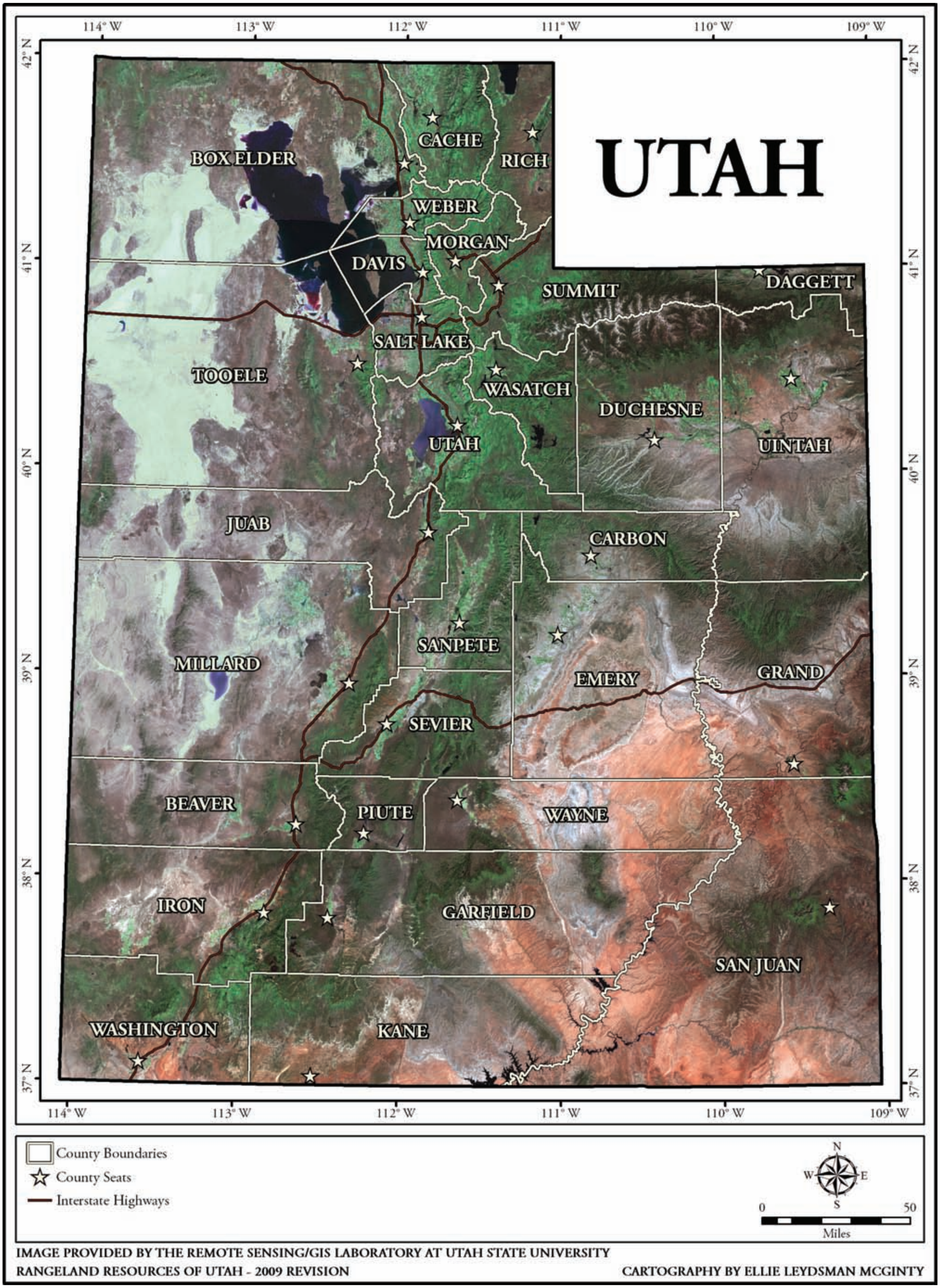
The 1989 *Rangeland Resources of Utah* publication was the template for this document. The primary objectives of the new document were to update data and trends and to provide up-to-date information. New sections have been included which pertain to relevant information and issues that have evolved since the late 1980s.

The intended audience of this document is the general public of Utah and those interested in Utah rangelands and the associated issues. Issues and topics are organized in a straightforward manner with extensive references of original data sources and information.

The goal was to compile, synthesize, and analyze the wealth of existing information and data on Utah rangelands. Often, the considerable volume of available information becomes overwhelming, and important details and trends can be lost. The guidelines were to use readily accessible, publicly available data sources and information from the public record. All calculations and synthesis of data were as minimal and transparent as possible, with all efforts made to retain the original source data. Information from the government agency responsible for the management or administration of the rangeland or the associated issue was used whenever possible.

Major advancements in geographic information systems (GIS) and remote sensing techniques since 1989 have enabled a more comprehensive overview. Environmental Systems Research Institute (ESRI) ArcGIS 9.3 was the software utilized to display and analyze data and to design maps. Primary data sources for this document include the following: Utah Automated Geographic Reference Center (AGRC), the Bureau of Land Management (BLM), Utah Division of Wildlife Resources (UDWR), the United States Geological Survey (USGS) National Map Seamless Server, the United States Department of Agriculture (USDA) Geospatial Data Gateway, Prism Climate Data, Daymet Climate Data, USDA Natural Resources Conservation Service (NRCS) STATSGO2 soil database, Federal Wildland Fire Occurrence Dataset, and USGS LANDFIRE (Landscape Fire and Resource Management Planning Tools Project). Each map provided within the document is accompanied with the relevant data sources.

The digital version of this document is available online at: http://extension.usu.edu/utahrangelands.


UTAH
114° W
113° W
112° W
111° W
110° W
109° W
42° N
41° N
40° N
39° N
38° N
37° N
BOX ELDER
CACHE
RICH
WEBER
MORGAN
DAVIS
SUMMIT
DAGGETT
SALT LAKE
TOOELE
WASATCH
DUCHESNE
UTAH
UINTAH
JUAB
CARBON
SANPETE
MILLARD
EMERY
GRAND
SEVIER
BEAVER
PIUTE
WAYNE
IRON
GARFIELD
SAN JUAN
WASHINGTON
KANE
County Boundaries
County Seats
Interstate Highways
N
W
E
S
0
50
Miles
IMAGE PROVIDED BY THE REMOTE SENSING/GIS LABORATORY AT UTAH STATE UNIVERSITY
RANGELAND RESOURCES OF UTAH - 2009 REVISION
CARTOGRAPHY BY ELLIE LEYDSMAN MCGINTY

Introduction

Neil E. West

Utah has been predominantly a rangeland state for more than 150 years. Approximately three-quarters of the landscape is dry, sparsely vegetated, and either uncultivated or not permanently occupied by humans. Nevertheless, these lands provide habitat for numerous species of plants and animals, produce water for irrigation, recreational, and culinary uses, are the site for extensive extraction of minerals and fossil fuels, serve as open space for dilution of pollutants, and offer a wide variety of outdoor recreational activities, including those within designated wilderness. Grazing by livestock has been an important economic activity since Europeans began their colonization. While the use of these forages has been increasingly controlled through time, access to them remains essential for maintenance of the local food and fiber production stream.

Roughly three-quarters of Utah is publicly owned land. The overlap of rangelands and this ownership pattern is predominantly coincidental. Because the bulk of the public-owned rangelands are under federal control, decisions on their use and management will continue to not be made by the citizens of Utah alone. Hence, the stewardship of federal lands will be increasingly driven by issues on the national agenda. Since the viability of local enterprises depends on access to these federal lands, it behooves all to better understand where different kinds of rangelands are located, who controls them, and how these differing ecosystems are put together, function, and change under alternative management scenarios.

If Utah is to concurrently achieve a robust economy and high-quality environment for all its citizens, the health of Utah rangelands must be continually enhanced. In the following, the status of rangelands, in their entirety, is reviewed. This is an update of the 1989 first edition. New data and scientific knowledge has been incorporated, and advanced technological tools (especially remote sensing and geographic information systems) have been employed to make this new overview more accurate and comprehensive than possible in 1989. Hopefully this document will help further the process of cooperative resource management necessary to achieve improved rangeland health across the state.

History of Utah

Ellie I. Leydsman McGinty

NATIVE AMERICAN INDIANS

Prior to Euro-American settlement, the Great Basin-Colorado Plateau region was inhabited by Native American Indians. Anthropologists, archeologists, and historians have identified several Indian cultures, including the Desert, Basket Maker, Pueblo, Fremont, Ute, Paiute, Goshute, Shoshoni, and Navajo (Tyler, 1989). The earliest known inhabitants were primitive nomadic hunter-gatherers of the Desert Culture who occupied the region between 10,000 B.C. and A.D. 400 (Lewis, 1994a).

Beginning in A.D. 400, the Anasazi Culture began to move into present-day southeastern Utah from south of the Colorado River. Anasazi, a Navajo word which means "the ancient ones," refers to the early Anasazi period Basket Maker Culture (A.D. 400 to 700) and the later Anasazi period Pueblo Culture (A.D. 700 to 1300) (Tyler, 1989). The Anasazi Cultures were sustained by hunting-gathering techniques and a growing dependence on semi-agricultural systems that incorporated a maize-bean-squash horticultural component. The Anasazi Cultures built masonry dwellings in cliff caves, mesa tops, and sheltered canyons, as depicted at Mesa Verde National Park, Hovenweep National Monument, and Grand Gulch (Lewis, 1994a). The Pueblo Culture prospered in present-day Utah until A.D. 1300 when they withdrew from their settlements in the San Juan River drainage and retreated to pueblo villages in New Mexico and northern Arizona. Climatic changes, crop failure, and the intrusion of nomadic tribes are attributed to the decline of their culture (Tyler, 1989; Hurst, 1994).

Parallel to the Anasazi Culture, the Fremont Culture began to emerge in central and northern Utah in A.D. 400. The Fremont Culture, a society characterized by variation, diversity, and adaptability, retained some of the traits of the Desert Culture, while simultaneously developing similar Basket Maker-Pueblo characteristics and integrating the maize-bean-squash horticultural component. Near the end of the thirteenth century, a cultural regression occurred among the Fremont Culture, which corresponded to the retreat of the Anasazi from southwestern Utah. The Fremont people were likely displaced by or assimilated into cultures of hunter-gatherers who were ancestors of the Numic-speaking Shoshoni, Goshute, Paiute, and Ute Native American Indians (Tyler, 1989; Madsen, 1994a).

Numic- or Shoshonean- speaking cultures of the Uto-Aztecan language family began to enter the Great Basin region from Death Valley sometime after A.D. 1000. They evolved into four distinct groups: the Northern Shoshone, Goshute or Western Shoshone, Southern Paiute, and Ute (Lewis, 1994a). The Northern Shoshone, a culture that occupied northern Utah, southern Idaho, and Wyoming, were hunter-gatherers who adopted many traits of the nomadic Plains Indians through trade (Tyler, 1989). Their diet consisted of fish and waterfowl found in the Bear, Weber, and Snake river drainages, as well as grouse, large game, beavers, badgers, and rabbits (Rogers, 2000). The Goshute (Kusiutta) inhabited the arid and formidable desert regions to the southwest of the Great Salt Lake. The Goshute were proficient and adaptive hunter-gatherers, as they had an understanding of growing cycles, variations in climate, and animal distribution patterns. Their culture was sustained by seasonal seeds, grasses, roots, insects, larvae, small reptiles. They also hunted antelope, deer, and rabbits (Lewis, 1994a; Defa, 1994).

The Southern Paiute (Nuwuvi) occupied the southwestern region of Utah where the Great Basin and Colorado Plateau converge. While the largest population concentrations were along the Virgin and Muddy rivers, many Paiutes adapted to the surrounding arid desert environments. Both riverine and desert groups combined their hunting-gathering subsistence techniques with some floodplain or irrigated agriculture (Holt, 1994; Lewis, 1994a). The Ute Indians (Nuciu) were geographically separated into eastern and western groups. The eastern Utes inhabited the high plateaus and Rocky Mountains of Colorado and northern New Mexico, while the western Utes, or Utah Utes, occupied the central and eastern two-thirds of Utah. The Utes practiced a flexible hunting-gathering subsistence system and adopted the horse and buffalo culture of the Plains Indians. The Utah Utes benefitted from the abundance of fish in Utah Lake (Lewis, 1994b).

Ethnically and linguistically distinct from the Numic-speaking cultures of the Great Basin and Colorado Plateau, the Athabaskan-speaking Navajo (Dine) migrated to present-day southwestern United States from the subarctic of western Canada between A.D. 1300 and 1400 (Lewis, 1994a). In A.D. 1700, the Navajo entered the San Juan River drainage area of southeastern Utah in search of pasture for sheep and goats they acquired from the Spaniards. The Navajo were skillful hunter-gatherers who incorporated domestic livestock and agriculture into their subsistence system. The San Juan River, one of the few reliable sources of water in the Navajo territory, permitted plantings of maize, beans, and corn on floodplains and tributaries (McPherson, 1994).

EARLY EXPLORATION

Historic accounts written by Pedro de Castaneda, the chronicler of the Coronado expedition, suggest that Don Garcia Lopez de Cardenas may have entered southeastern Utah in 1540 in search of a large river reportedly lying northwest of Tusayan, the Hopi villages in northeastern Arizona. Additional accounts during the periods of the Cortez and Coronado expeditions mentioned the lands of Lake Copala and El Gran Teguayo located to the northwest of the pueblo villages of New Mexico and Arizona. Historians presume that these lands were probably in the vicinity of Utah Lake and Great Salt Lake (Warner, 1989).

During the 1760s, the Spaniards developed a fervent interest to explore the lands north of New Mexico and Arizona. The previously documented accounts from two centuries prior, in addition to the aspiration of expanding the Spanish Empire, prompted New Mexican authorities to send expeditions northward. Explorer Juan María Antonio Rivera was instructed by the government to explore the Río del Tizon, the Colorado River, and to learn the extent of Indian settlements in the north. Rivera and his party traveled along well-worn Spanish and Ute-trader trails, moving northward into the Dolores River drainage in Colorado. In October of 1765, Rivera ventured into unfamiliar territory, crossing into Utah northeast of Monticello and travelling into the Lisbon Valley and Spanish Valley (Alexander, 1996).

In 1776, the year of the nation's declaration of independence, the Spanish friars Francisco Atanasio Domínguez and Silvestre Vélez de Escalante from Santa Fe, New Mexico, were instructed by their ecclesiastical superiors in Mexico City to find an overland route between the mission in Santa Fe and the recently established mission in Monterey, California (Alexander, 1996; Johnson and Anderson, 1989). Although their directive was not successfully executed, their exploration provides some of the first detailed records of present-day Utah (Peterson, 1977).

The Domínguez-Escalante Expedition entered the present state of Utah on September 11, 1776, passing through the area where Dinosaur National Monument is today. The friars directed their course to the southwest until they arrived at the junction of the Uinta River (Río de San Damián) and the Duchesne River (Ribera de San Cosme). The expedition traveled westward and ascended the Duchesne and Strawberry Rivers to the rim of the Great Basin. They descended along the Diamond Creek River (Río de San Lino) to the Spanish Fork River (Río de Aguas Calientes), where they were subsequently directed to Utah Valley and the settlements of the Laguna or Timpanogot (Ute) Indians on the eastern shores of Utah Lake. They arrived on September 23-24, 1776 (Warner, 1989). Domínguez and Escalante gave Utah Valley the name of La Valle de Nuestra Señora de la Merced de los Timpanogotzis, describing the great valley and the lake of the Tympanocuitzis as an inviting Spanish settlement with abundant resources and a docile and affable nation of Indians (Peterson, 1977; Warner, 1989; Alexander, 1996).

From Utah Valley, the Domínguez-Escalante Expedition proceeded toward Monterey, California, passing through Juab Valley, across Scipio Pass, and through the Beaver River drainage to present-day Milford. However, in early October 1776, an intense snowstorm with intolerable cold prompted a momentous decision by Domínguez and Escalante to abandon the quest for Monterey and to return to Santa Fe. On October 11, 1776, the members of the expedition cast lots to validate the decision. The explorers directed their course to the south through Cedar Valley, down Ash Creek, and across the Virgin River where they encountered the high tablelands of the Colorado River. Exploration ensued to find a place where the river could be forded. On October 26, 1776, an attempt to cross the Colorado River at the mouth of the Paria River failed. The crossing was eventually accomplished on November 7, 1776, at a location about 33 miles below the mouth of the San Juan River, 3 miles north of the present Utah-Arizona boundary. After crossing the Colorado River, the expedition proceeded southward to Hopi villages and Spanish missions, eventually arriving in Santa Fe on January 2, 1777 (Warner, 1989; Johnson and Anderson, 1989).

Beginning in 1821, many fur trading companies and individual trappers began to occupy the Rocky Mountains and Intermountain West, as insatiable American and European markets for fur and pelts flourished. In 1824, fur trappers, later referred to as mountain men, entered Utah from three directions. Americans enlisted with the William Ashley-Andrew Henry Fur Company came from St. Louis; the Hudson's Bay Company traveled from the north and northwest; and independent French-Canadian-American trappers journeyed from New Mexico, primarily Taos and Santa Fe (Miller, 1989a).

A group of Ashley-Henry trappers, under the lead of Jedediah Smith and Thomas Fitzpatrick, reached the upper Sweetwater River early in 1824 and turned westward to cross the Continental Divide by way of South Pass. Although South Pass had been traversed in 1812, the rediscovery of the pass represented a landmark for fur trappers, missionaries, goldrushers, and Mormons, as it became the major thoroughfare to the Great Basin. During the summer of 1824, John Weber, one of the most prominent members of the Ashley-Henry Fur Company, and his brigade crossed South Pass and Green River Valley and descended into the Bear River region and Cache Valley for the fall hunt (Alexander, 1996; Miller, 1989a). James Bridger, a member of John Weber's brigade, became a distinguished trapper, hunter, trader, and frontiersman. He is also recognized as one of the first documented discoverers of the Great Salt Lake (Despain and Gowans, 1994).

The British Hudson's Bay Company, led by Peter Skene Ogden, set out from the company's Flathead Post in Montana on December 20, 1824. The brigade worked their way to the Bear River near the present site of Alexander, Idaho, and followed the river southward into Cache Valley. From the south end of Cache Valley, the brigade traversed into Ogden Valley. While Peter Skene Ogden and his brigade were traveling through Cache Valley, American trappers followed the Bear River to its mouth and explored southward along the front of the Wasatch Range (Miller, 1989a).

As American and British fur companies were exploring the regions in northern Utah, Taos Trappers, including Etienne Provost and Antoine Robidoux, ranged into the San Juan, Colorado, Green, and Duchesne River drainages, and eventually voyaged into the Great Basin and Wasatch Mountains. In 1824, Etienne Provost, the most notable trapper operating from the Taos base in New Mexico, entered Utah by the same general route as Catholic missionary-explorers had in 1776 (Miller, 1989a). Provost followed the Duchesne River to the river that bears his name, the Provo River, and followed it to Utah Lake. Some historians affirm that Provost may have been the first Euro-American to see the Great Salt Lake (Nichols, 1995).

In May of 1825, conflict and conspiracy between American and British trappers at Deserter Point on the Weber River forced Peter Skene Ogden to retreat to the Snake River. American trappers continued to trap and trade in Utah even though the area legally belonged to Mexico. For over a decade, the Ashley-Henry Fur Company had tapped the richest fur areas in the West, and in turn, William Ashley developed a new system whereby fur supplies were brought to designated locations in the West. This social business activity became known as the annual rendezvous. The first rendezvous was held at Henry's Fork of the Green River; the next one in Cache Valley; the next two on the south end of Bear Lake; and the remainder were held in southwestern Wyoming and eastern Idaho until their discontinuance in 1840 (Alexander, 1996; Miller, 1989a).

Through this wide-ranging activity, much of modern Utah was documented, described, and named. Renowned mountain men, including William Ashley, Jedediah Smith, John Weber, James Bridger, Peter Skene Ogden, and Etienne Provost, made significant contributions to the knowledge of the West by providing the foundation for later detailed exploration and mapping. Scientific and military expeditions conducted by John C. Fremont, John W. Gunnison, Howard W. Stansbury, and John Wesley Powell yielded detailed documentation of the Utah landscape (Johnson and Anderson, 1989).

John C. Fremont, an officer in the Topographical Corps of the United States, led five expeditions into the West. The 1843-44 expedition undoubtedly had the greatest impact. He surveyed the vast region he appropriately named the Great Basin and he traversed across the Salt Lake Desert. He recorded detailed descriptions of the soil, vegetation, and wildlife, and he made reference to the valleys as locations for future settlement (Spence, 1994; Miller, 1989b; Peterson, 1977; Alexander, 1996). While Mormons began to settle the Utah region in 1847, scientific explorations continued. Of momentous importance were the expeditions conducted by John Wesley Powell. In 1867, John Wesley Powell, an appointed professor of geology, commenced a series of expeditions to the Rocky Mountains and the canyons of the Green and Colorado rivers. Powell and his party journeyed 900 miles with four boats, traveling from the Union Pacific Railroad crossing of the Green River in Wyoming down through the Grand Canyon (Bearnson, 1994).

COLONIZATION AND SETTLEMENT

On July 24, 1847, Mormon (Latter-day Saint) pioneers entered the Great Salt Lake Valley from Emigration Canyon. The westward migration was prompted by unyielding religious persecution in New York, Ohio, Missouri, and Illinois that had culminated in the assassination of their prophet and leader, Joseph Smith. The new prophet of the Mormon Church (Church of Jesus Christ of Latter-day Saints), Brigham Young, made a definitive commitment to move west when it became apparent that the Mormons could not peacefully survive in Nauvoo, Illinois. The Great Salt Lake Valley was chosen as an isolated location where they could practice their faith in comparative freedom (Campbell, 1989a; Hill, 1989; Johnson and Anderson, 1989).

Within days of their arrival to the Salt Lake Valley, the Mormon pioneers cooperatively established a base settlement for growing crops and building homes (Alexander, 1996). Thirty-five acres of cropland were staked out, plowed, and irrigated for planting potatoes, corn, buckwheat, beans, turnips, and other crops. The city of Salt Lake was laid out in 135 ten-acre blocks, with a site for a temple in the center. The blocks were subdivided into one-and-a-quarter-acre town lots, which loosely replicated the plat of the City of Zion that was designed by Joseph Smith. Within a month, 29 log houses were built within the walls of an adobe fort (Campbell, 1989b; Alexander, 1996).

Although the primary emphasis of the Mormons was to establish a base of operations in the Salt Lake Valley, leaders directed parties of explorers to investigate the surrounding territory and to document the availability and abundance of natural resources. Brigham Young led a party around the Salt Lake Valley; Albert Carrington, an apostle of the Mormon Church, and two men surveyed the southern end of the Salt Lake Valley; and Jesse Little, an ordained leader, and three companions explored the northern end of the Salt Lake Valley into the Bear River Valley and eastward into Cache Valley (Alexander, 1996; Campbell, 1989b).

While pioneers continued to enter the Salt Lake Valley, plans to establish additional colonies were initiated. Within the first year, small towns were settled in Salt Lake Valley and Weber Valley. Bountiful and Farmington were founded in 1847. Ogden was founded in 1848 with the acquisition of Fort Buenaventura, a trading post built by trapper and trader Miles Goodyear. Centerville, Holladay, and West Jordan were also founded in 1848 (Arrington, 1994). In 1849, colonies were established in Utah, Tooele, and Sanpete valleys. Utah Valley, which impressed Domínguez and Escalante, James Bridger, and John C. Fremont, became a logical place for an early settlement. Tooele Valley, a location separated from Salt Lake Valley by the Oquirrh Mountains, was partially explored by Brigham Young in 1847. Thorough exploration of Tooele Valley in 1849 encouraged colonization on Settlement Creek. In the fall of 1849, 50 families journeyed to Sanpete Valley and established the town of Manti. On November 23, 1849, Parley Pratt, another prominent church apostle, guided a group of 50 persons to determine locations for settlement between the Salt Lake Valley and the Santa Clara Valley. Detailed reports from this exploration became the foundation for establishing a line of colonies from Utah Valley to the Sevier and Virgin rivers (Campbell, 1989c).

From 1847 to 1857, 90 settlements were founded, from Wellsville and Mendon in the north to Washington and Santa Clara in the south. This period of settlement signified the founding of the north-south line of settlements along the Wasatch Front and Wasatch Plateau. As immigration proceeded throughout the 1850s, settlements multiplied. However, during the second decade of settlement, the approach of the Utah Expedition of General Albert Sidney Johnson threatened settlement in outlying areas. The Utah Expedition, commonly referred to as the Utah War, was an armed dispute between Mormon settlers in the Utah Territory and United States Federal Government. The confrontation began in May 1857 and was ultimately resolved in July 1858 through negotiation. During the 10 years after the Utah War, 112 new communities were founded in Utah. Settlements in Bear Lake Valley, Cache Valley, Pahvant Valley, Sevier River Valley, Virgin River Valley, and Muddy River Valley were established. Important cities that were founded during this period include Logan (1859), Gunnison (1859), Morgan (1860), St. George (1861), and Richfield (1864) (Arrington, 1994).

During the following decade of settlement, 93 new settlements were established. Continued expansion occurred in Cache Valley, Bear Lake Valley, the Sevier River Basin, and on the east fork of the Virgin River. Several residents of Sanpete Valley migrated across the eastern mountains and established new settlements in Castle Valley (Emery County), along the Price River (Carbon County), along the Fremont River (Wayne County), and along Escalante Creek (Garfield County). In the remaining years of the nineteenth century, new colonies were founded in the few remaining places that could be irrigated (Arrington, 1994). By 1877, Brigham Young and other renowned Mormon leaders planned and supervised the migration of approximately 80,000 Mormons and facilitated the establishment of over 300 settlements in and near the Great Basin (Campbell, 1989c).

POLITICAL DEVELOPMENT

From 1535 to 1820, the Spanish claimed a political unit of Spanish territories referred to as the Viceroyalty of New Spain. These lands included present-day southwestern United States, Mexico, and Central America. The vast expanses north of New Spain, including present-day Utah, were explored in 1776 by Domínguez and Escalante, and accordingly claimed by the Spanish Empire. The Mexican War of Independence (1810-1821) resulted in the expulsion of the Spanish colonial government with the authorization of the Treaty of Córdoba. Consequently, Mexico gained independence as a constitutional monarchy and acquired the lands presently defined by the country of Mexico and the states of California, Nevada, Arizona, New Mexico, Texas, Colorado, and Utah (Tyler, 1989; Alexander, 1996).

In February 1848, with the Treaty of Guadalupe Hidalgo, the present states of California, Nevada, Arizona, and Utah were ceded to the United States by Mexico, as well as portions of Arizona, New Mexico, Colorado, and Wyoming. This cession, commonly referred to as the Mexican Cession of 1848, was a condition for the end of the Mexican-American War (Johnson and Anderson, 1989). Once Utah became part of the United States, Mormons formed a theodemocratic political government, the People's Party, and petitioned Congress to designate the region they occupied as the State of Deseret. The State of Deseret encompassed the Great Basin, the Colorado River Basin, and a corridor to the Pacific Ocean around San Diego (Poll, 1994). However, the application for statehood was denied by the government of the United States because lawmakers were not inclined to grant the Mormons control over such a vast domain (Campbell, 1989d; Lyman, 1994).

However, Utah was organized as a territory of the United States on September 9, 1850, under an Organic Act of Congress and as part of the Compromise of 1850. The Compromise of 1850 attempted to resolve the territorial and slavery controversies caused by the Mexican-American War by admitting California into the Union as a free state and creating the territories of Utah and New Mexico (Johnson and Anderson, 1989; Campbell, 1989d). The Utah Territory embraced over 220,000 square miles; extended from the Continental Divide in Colorado and Wyoming to the California state line; and spanned the width from the 37th and 42nd parallels of latitude. Within the following two decades, the extent of the Utah Territory was reduced as mining developments in California and Colorado expanded, as migration and transportation routes were established, and as social, cultural, and political conflicts heightened between Mormons and non-Mormons. In 1861, the territories of Nevada and Colorado were formed in whole or part from the Utah territory, and an addition to the territory of Nebraska was made. Further portions of the territory were allocated to Nevada in 1862 and 1866 and to Wyoming in 1868. These events formed the present borders of the state of Utah (Johnson and Anderson, 1989).

Throughout this period of territorial development in the western United States, Mormon leaders made additional attempts to gain statehood, as statehood was considered integral to independence in local affairs. In 1856, Mormons sent Congress a draft of a constitution for a state much smaller than the proposed State of Deseret. Simultaneously, the Republican Party's first presidential campaign was featuring a platform that denounced slavery and polygamy. This denouncement produced friction between the federal government and the Mormons, and eventually resulted in the Utah War (1857-1858) (Lyman, 1994).

A third effort to acquire statehood occurred in 1862, but serious consideration was not given by Congress because legislation prohibiting plural marriage was in the process of being enacted. The fourth attempt, occurring in 1876, was unsuccessful because executive and legislative leaders pronounced that statehood was not possible as long as plural marriage continued to be condoned and practiced in the territory of Utah. In 1882, the territorial legislature devised a new plan to obtain statehood. The plan entailed the request of a republican form of government that provided the citizens of the Utah Territory with the liberties sought by the founding fathers of the nation. Although the Mormons presented appropriate legislation to Congress, the request was ignored (Lyman, 1994). In 1887, a sixth organized effort for statehood was initiated that involved the submission of a state constitutional clause that recognized polygamy as incompatible with a republican form of government. This elaborate attempt at statehood met the same fate as its predecessors (Larson, 1989).

After six unsuccessful bids for statehood were made between 1849 and 1887, Mormon leaders realized that the unsettled church-state conflict needed to be resolved in order to be admitted to the Union. Therefore, the leaders of the Utah Territory affirmed that the church would not advocate new plural marriage in defiance of the laws of the land. Additionally, the Mormon People's Party was quietly disbanded, and members were encouraged to join the recently organized Republican and Democrat parties. This final endeavor resulted in the Utah Enabling Act of 1894;

however, it was stipulated that Utah not be admitted until after the current congressional term. Consequently, Utah was finally admitted as the 45th state of the Union on January 4, 1896 (Lyman, 1989; Larson and Poll, 1989).

THE LIVESTOCK INDUSTRY AND RANGE MANAGEMENT

The introduction of livestock into the western United States is associated with exploration and colonization. In 1540, the Spanish explorer Francisco Coronado journeyed from Mexico northward into Arizona, New Mexico, and Colorado with a large number of cattle, sheep, hogs, horses, and mules (Sampson, 1952; Stoddart et al., 1975). Subsequent explorations were helpful in extending colonies and livestock into the southwestern and western United States. Spanish missions established in Texas, New Mexico, and Arizona became livestock centers in the early 1700s (Stewart, 1936; Sampson, 1952).

The first documented account of livestock in Utah was in 1845 when Miles Goodyear built Fort Buenaventura and brought livestock from Santa Fe to graze near the fort. Goodyear built the enclosed fort on the Weber River near present-day 28th Street in Ogden. However, the first considerable amount of livestock in Utah was brought by Mormon pioneers. Beginning in 1847, Mormons began to fill Utah ranges with foundation stock they drove across the Plains, and with lean cattle and horses obtained by trading with other emigrants. In total, they brought with them 358 sheep, 887 cattle, 2,213 oxen, 35 hogs, 124 horses, and 716 chickens (Stewart, 1936; Sampson, 1952; Jacobs, 1984). On November 25, 1847, Miles Goodyear sold Fort Buenaventura and most of his livestock to the Mormons, and subsequently, they acquired an additional 75 cattle, 75 goats, 12 sheep, and six horses (Sadler, 1994; Jacobs, 1984).

During the following years, livestock markets and production were stimulated by the California Gold Rush (1848–1855) and the Civil War (1861–1865). Large herds were driven to California from Mexico, Arizona, and New Mexico. The demand for meat and animal products during the Civil War brought large cattle shipments from Texas to the Confederate Army (Stewart, 1936; Sampson, 1952). The inflationary period after the Civil War and the completion of the first transcontinental railroad in 1869 initiated a livestock boom which affected much of the western United States. The development of mining camps in the Great Basin also brought a great demand for wool and mutton (Knapp, 1996).

While the Mormon pioneers were establishing settlements in the Salt Lake Valley, Brigham Young took possession of Antelope Island in the Great Salt Lake for use as a herd ground for livestock. However, Antelope Island became overstocked with grazing animals, so Brigham Young sent large numbers of horses and cattle to new range near the Sevier River. In 1855, a number of families moved a substantial amount of cattle, sheep, and horses to high-quality rangeland in the south end of Rush Valley. By 1875, the range in Rush Valley was extremely depleted, and cows were calving only every other year. Grazing problems in Utah became acute, and it was recognized that principles of good range management had not been learned by the settlers (Jacobs, 1984).

By 1890, the last western open range was fully stocked. It is estimated that there were over 26 million cattle and 20 million sheep in the 17 western states. The resulting competition for forage between cattle and sheep was intense. While cattle and sheep competed for many of the same resources, the impact of sheep on the landscape was greater than that of cattle. Cattle were confined to relatively gentle terrain in sagebrush-bunchgrass ecosystems, whereas sheep could travel into steeper and rougher terrain (Knapp, 1996). As an outcome, range and forest lands were heavily overgrazed and depleted, and stockmen of both factions engaged in bitter disputes over land (Stewart, 1936; Sampson, 1952). High-elevation watersheds on the Wasatch Plateau in central Utah were severely overgrazed, resulting in catastrophic flooding in the adjacent communities of Manti and Ephraim (Prevedel et al., 2005).

As an initial solution to halt overgrazing, the federal government began managing livestock grazing on the established forest reserves. In 1902, Sanpete Valley citizens petitioned the federal government to establish another forest reserve above Manti. Subsequently, President Theodore Roosevelt signed the proclamation creating the Manti Forest Reserve. In 1905, the jurisdiction of the existing forest reserves was transferred from the General Land Office to the Bureau of Forestry in the Department of Agriculture. The agency was shortly renamed the Forest Service, and Gifford Pinchot, the Chief of the Forest Service, imposed grazing fees and established a use-by-permit system (Prevedel and Johnson, 2005). The establishment and expansion of the National Forest system virtually ended the range wars and marked the beginning of scientific range management (Sampson, 1952; Stoddart et al., 1975).

During the 1910s and 1920s, scientific and professional techniques of range management were adopted. Region 4 of the Forest Service established a research station as a model for the implementation of research-validated models. In 1912, the Great Basin Experiment Station was established in Ephraim Canyon on the Manti Forest. Arthur W. Sampson, who is noted for his range and forest research, became the first director, and his research became models for range reconnaissance and carrying-capacity studies. Sampson's work in Utah also provided the justification for deferred and rotation grazing (Alexander, 1987). This practice of technical professionalism and experimentation initiated close cooperation between scientists and range managers and allowed rapid implementation of the research results. Subsequently, it helped Region 4 to develop the capacity to adopt changing techniques and implement effective range management in the Intermountain West. Additionally, long-term records and early studies evaluating the impacts of various levels of grazing at the Great Basin Experimental Station contributed to the advancement of methods in rangeland restoration (Alexander, 1987; Lugo et al., 2006).

In 1933, the Desert Experimental Range in Pine Valley, approximately 40 miles west of Milford, was established. President Herbert Hoover provided the basis for the Desert Experimental Range when he withdrew 87 square miles of land from the public domain as an agricultural range experiment station. The development of the experimental range was prompted by concern for the condition of public rangelands. Expanses of Great Basin rangelands dominated by low shrubs had nearly become devoid of vegetation (Clary and Holmgren, 1982). In the winter of 1934-35, sheep grazing studies were initiated to study the economic and ecological impacts of grazing at different intensities, seasons, and frequencies (Adams et al., 2004). Early studies concluded that poor range condition was a result of improper grazing practices rather than the cyclical periods of drought. Restoration efforts were attempted; yet cultural improvement practices using planting techniques were not successful. Subsequent studies indicated that range recovery was possible given that higher levels of grazing during the winter months were not permitted and that grazing was not allowed to repeatedly occur on the same area year after year during the late winter-early spring months (Clary and Holmgren, 1982).

The progression of scientific range management was accompanied by additional legislation which sought to regulate grazing on public lands. The Taylor Grazing Act of 1934 created the Grazing Service (presently the Bureau of Land Management) and authorized the establishment of grazing districts on public domain lands that were considered to be valuable for grazing and raising forage crops. This act also established the permit and leasing system on public lands and defined the requirements for the distribution of funds received from grazing. In 1976, the Federal Land Policy and Management Act was established to limit the length of permits and leases to 10 years and to regulate seasonal limits on grazing. In 1978, the Public Rangeland Improvement Act required the Bureau of Land Management and Forest Service to inventory and manage lands in the western states with the commitment to improve the conditions on public rangeland. As a component of this commitment, the grazing fee formula was established to account for cattle density and forage consumption (US GAO, 2005).

Land Ownership of Utah

Ellie I. Leydsman McGinty

Utah has a unique land ownership structure that yields administration by various federal, state, tribal, and private entities (Figure 2.1; Tables 1, 2, and 3 in Appendix A). The federal government, through executive departments, administers lands owned by the Bureau of Land Management, the United States Forest Service, the National Park Service, the Department of Defense, and the United States Fish and Wildlife Service. Utah government agencies, including the State of Utah School and Institutional Trust Lands Administration, the Utah Division of Forestry, Fire, and State Lands, the Utah Division of Wildlife Resources, and the Utah Division of State Parks and Recreation, correspondingly manage state trust lands, state sovereign lands, state wildlife reserves, and state parks. Private lands are owned and managed by corporate or individual titleholders. Tribal trust lands are cooperatively administered by the Bureau of Indian Affairs and the Native American Indian tribes that own the land. Based on the Utah land ownership data released in May 2009 by the State of Utah School and Institutional Trust Lands Administration and the Utah Automated Geographic Reference Center, federal lands comprise 64.3 percent of Utah; state lands comprise 10 percent of Utah; private lands comprise 21.1 percent of Utah; and tribal lands comprise 4.5 percent of Utah.

FEDERAL LANDS

Bureau of Land Management – Prior to the creation of the Bureau of Land Management (BLM), the General Land Office and the Grazing Service managed public domain lands. In 1812, Congress established the General Land Office as an independent agency of the United States government to administer public domain lands, with the primary purpose of transferring lands into private ownership under land disposal laws, such as the Preemption Act of 1841 and the Homestead Act of 1862. The General Land Office was placed into the Department of the Interior when it was formed in 1849. Public land sales in western territories and states during the nineteenth century were impressive. The first Utah land office was opened in Salt Lake City during January 1869 (Graham, 1994; Anderson, 1989).

During the late nineteenth century, concerns about land conservation arose. Beginning in 1900, the General Land Office began to focus their management on natural resource conservation. Lands, such as forested watersheds, were withdrawn from settlement and deemed valuable by Congress for resource values. The General Land Office shifted from the primary function of administering land sales to issuing leases and collecting fees from minerals off lands withdrawn from disposal. The Mineral Leasing Act of 1920 allowed leasing, exploration, and production of selected commodities, such as coal, oil, and gas (BLM, 2007a).

In 1934, with the passage of the Taylor Grazing Act, the Grazing Service was established to provide for the orderly use, improvement, and development of public domain lands pending final disposal. The remaining public domain lands were those not appropriated under the various land disposal acts, not granted to the state for support of public institutions, or not reserved for public uses (Graham, 1994; Anderson, 1989). In 1946, the General Land Office and the Grazing Service were merged to form the Bureau of Land Management. Following this union, it was realized that there were more than 2,000 unrelated and often conflicting laws for managing public lands. Consequently, the Bureau of Land Management did not have a unified legislative mandate. The discrepancies within the agency were not resolved until Congress enacted the Federal Land Policy and Management Act of 1976. This legislation established a coherent set of laws for managing public lands, and it declared the remaining public lands were to be retained by the federal government and administered by the Bureau of Land Management under a concept of multiple-use management (Anderson, 1989; Graham, 1994).

The Bureau of Land Management is the primary land administrator in the state. The agency oversees more than 22.8 million acres of land. This equates to approximately 42 percent of the land area in the state. The Bureau of Land Management in Utah is structured into four regional district offices, including the West Desert District, the Green River District, the Canyon Country District, and the Color Country District. Within each district, there are field offices and corresponding resource management areas. The West Desert District includes the Salt Lake and Fillmore field offices; the Green River District includes the Vernal and Price field offices; the Canyon Country District includes the Moab and Monticello field offices; and the Color Country District includes the Richfield, Cedar City, Kanab, and St. George field offices. Additionally, the Bureau of Land Management in Utah manages the Grand Staircase-Escalante National Monument (GSENM), the

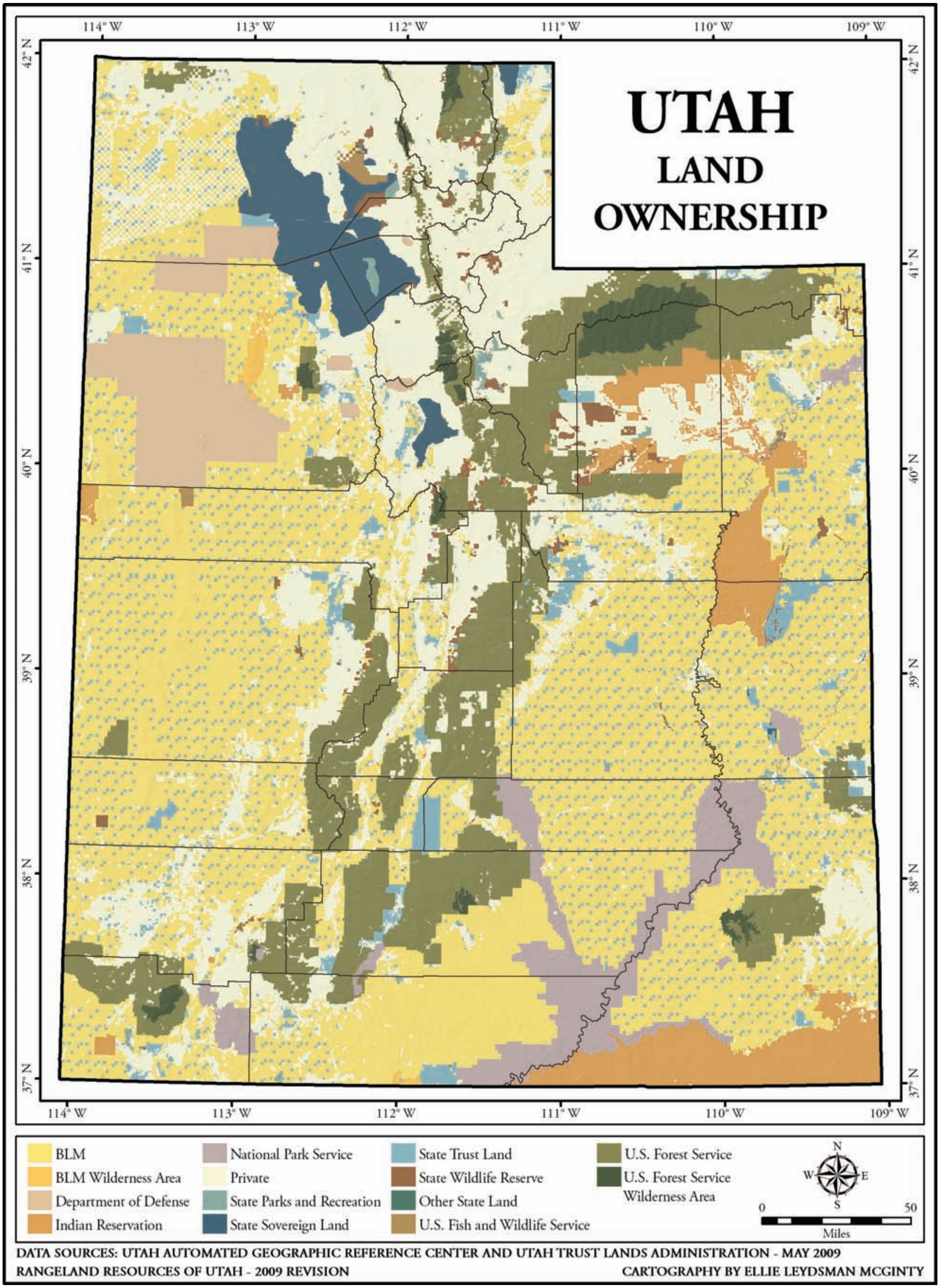


Figure 2.1. Land ownership of Utah.

first national monument to be administered by the BLM (Figure 2.2, Table 4 in Appendix A).

The Bureau of Land Management has a mission of sustaining the health, diversity, and productivity of public lands that encompasses multiple responsibilities. The BLM is accountable for managing natural resources, livestock grazing, fire, recreation, energy resources, and cultural resources. As part of their accountability, the BLM is obligated to manage special management areas, such as wilderness areas, wilderness study areas, areas of critical environmental concern, research natural areas, and outstanding natural areas (Figure 2.3; Tables 5, 6, and 7 in Appendix A). Additionally, with the approval of the Omnibus Land Bill, the Bureau of Land Management in Utah will be responsible for managing national conservation areas, additional wilderness areas, and several miles of wild and scenic rivers (BLM, 2009).

United States Forest Service – The history of the United States Forest Service dates back to 1876 when Congress approved an appropriations bill to fund a position to study and report on forest supplies and conditions. Franklin B. Hough received the appointment as a special forestry agent and he became the first federal expert on forestry with the responsibility of investigating forests and the lumber industry in the United States. Hough's *Report on Forestry* provided the foundation for the establishment of the United States Division of Forestry in 1881 (Steen, 1991; USFS, 2009).

Continued scientific investigations about forested watersheds and persistence by the American Forestry Association to acquire protection of federal forests eventually prompted Congress to pass the Creative Act of 1891. The Creative Act of 1891, also referred to as the Forest Reserve Act of 1891, was approved under the administration of Benjamin Harrison. The act included a provision that permitted the President of the United States to set aside forest reserves from the land in the public domain. President Harrison designated 15 forest reserves on over 13 million acres of forested land in seven western states and Alaska. None of these first forest reserves were located in Utah; however, it was not long before Utah citizens began to petition the General Land Office to protect several Utah watersheds that had been over-utilized from excessive sheep grazing and timber harvesting (Prevedel and Johnson, 2005; Nelson, 1997).

On February 22, 1897, President Grover Cleveland unexpectedly added 13 new forest reserves encompassing more than 21 million acres of land. The Uinta Forest Reserve was one of the new additions. This unforeseen addition to the forest reserve system generated protest that denounced the entire reservation system. Consequently, the forest reserves created by Cleveland were suspended for one year, and Congress, under the new administration of President William McKinley, authorized legislation for the practical administration of forest reserves. The Organic Act of 1897 was passed and it designated the purpose of the reserves to be for watershed protection and timber production. The Organic Act, considered to be one of the most important pieces of federal forest legislation, provided the main statutory basis for the management and protection of forest reserves in the United States (Steen, 1991; Prevedel and Johnson, 2005).

The Department of the Interior was responsible for federally administering the forest reserves; however, the Division of Forestry resided within the Department of Agriculture. Consequently, mismanagement and poor leadership prevailed. Attempts to transform the administration of forest reserves began in 1898 with the appointment of Gifford Pinchot as the fourth chief of the Division of Forestry. Pinchot campaigned to transfer the forest reserves to the Department of Agriculture (Prevedel and Johnson, 2005). In 1901, the Division of Forestry was renamed the Bureau of Forestry. Concurrently, the Secretaries of Interior and Agriculture worked out a formal agreement on the reserves. The Department of the Interior became responsible for patrolling the reserves and enforcing laws, while the foresters in the Department of Agriculture became responsible for making technical decisions and examining the reserves. Misadministration continued and further suggestions to transfer the reserves to the Bureau of Forestry within the Department of Agriculture were made (Prevedel and Johnson, 2005).

On February 1, 1905, the jurisdiction of the existing forest reserves was finally transferred from the General Land Office within the Department of the Interior to the Bureau of Forestry within the Department of Agriculture. The agency was shortly thereafter renamed the Forest Service, and Gifford Pinchot became the first chief of the United States Forest Service. During the formative years of the Forest Service (1901-1904), Albert Potter, an Arizona stockman and westerner, was appointed as a grazing expert of the forest reserves. In 1902, Potter traveled to Utah to conduct a survey of potential forest reserves. His evaluations of forested land in Utah were integral in the establishment of the forest reserves that are presently known as the Uinta-Wasatch-Cache, Manti-La Sal,

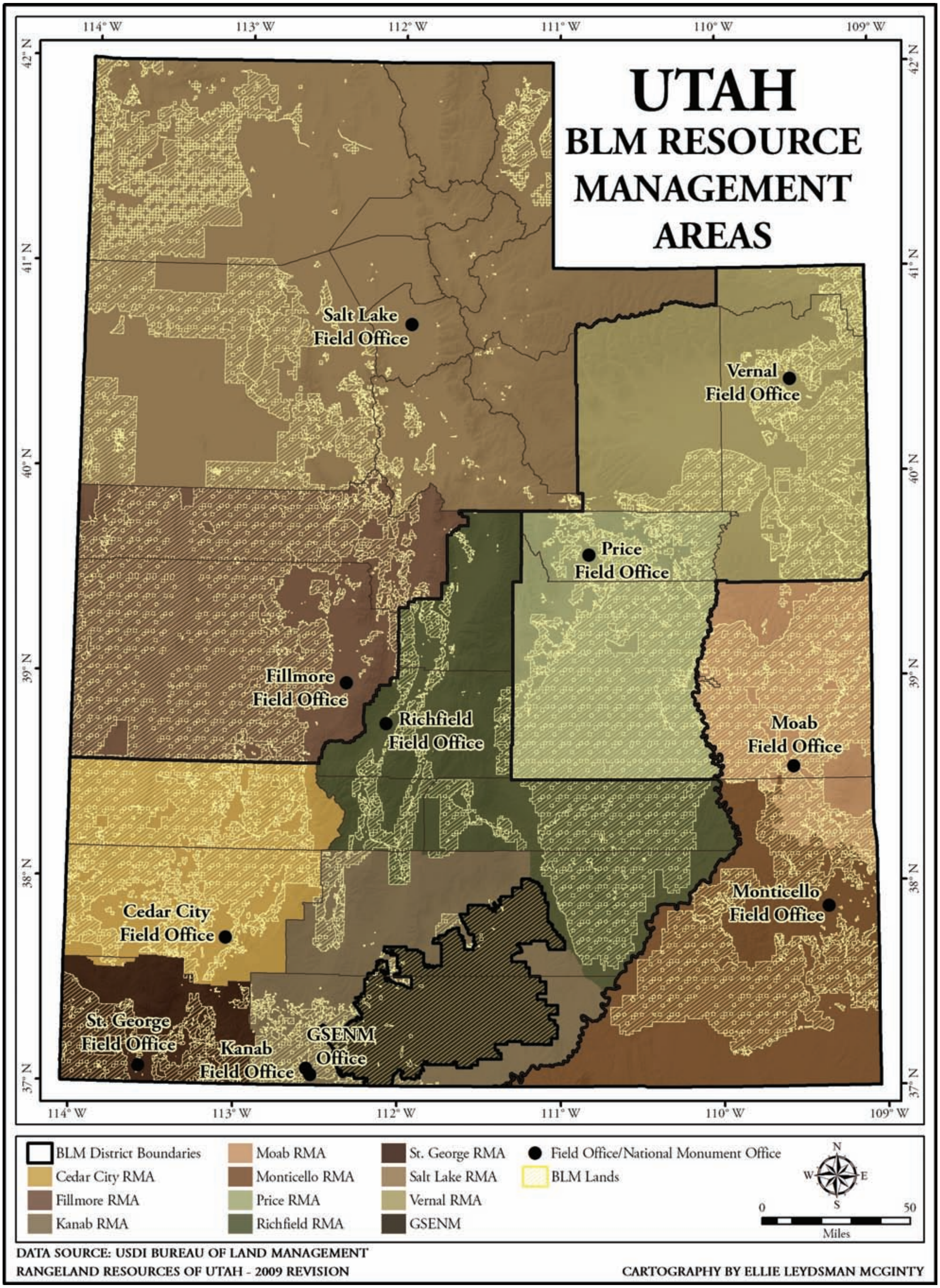


Figure 2.2. Bureau of Land Management resource management areas (RMAs) and field offices in Utah (reference Table 4 in Appendix A).

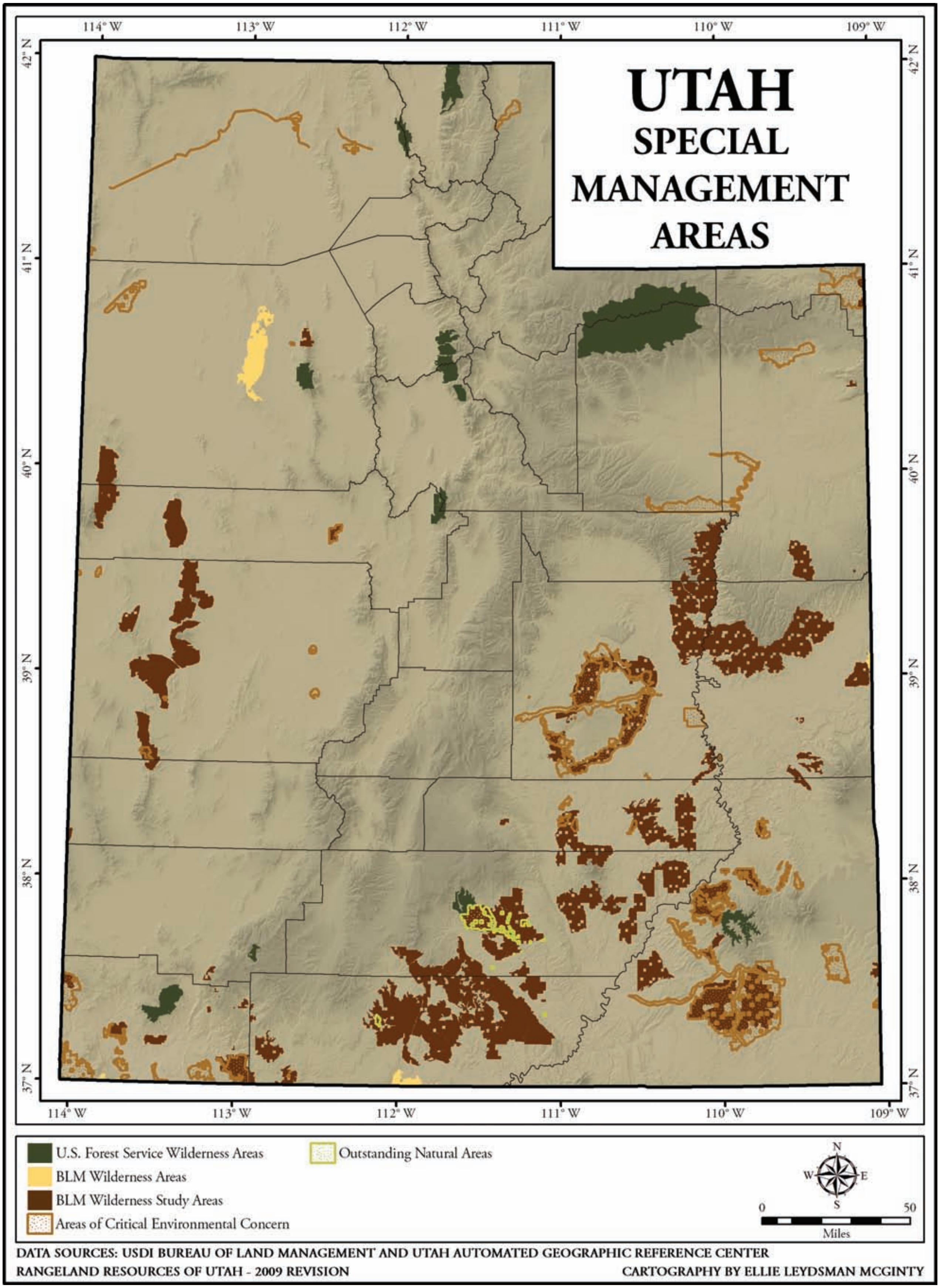


Figure 2.3. Bureau of Land Management and United States Forest Service special management areas in Utah.

Fishlake, and Dixie National Forests. Albert Potter also became the chief architect of the practical and effective Forest Service grazing policies and governing regulations (Prevedel and Johnson, 2005).

The United States Forest Service is the third largest land administrator in the state, managing approximately 15 percent of the land area. The agency oversees nearly 8.2 million acres of land. Of the 8.2 million acres, more than 767,000 acres are designated as wilderness areas (Figure 2.3; reference Table 8.5.3 in Recreation in Utah section), and nearly 92,000 acres are designated as a National Recreation Area (Flaming Gorge). In the state of Utah, there are seven national forests. Five of the national forests are entirely or primarily contained within the state. They include the Ashley National Forest, the Dixie National Forest, the Fishlake National Forest, the Manti-La Sal National Forest, and the Uinta-Wasatch-Cache National Forest. The other two National Forests extend into Utah from Idaho. They are the Caribou-Targhee National Forest and the Sawtooth National Forest (Figure 2.4). The current boundaries, land area, and names of the National Forests are the result of various reorganizations and consolidations that have occurred since the establishment of Utah's first forest reserve, the Uinta Forest Reserve, in 1897.

The United States Forest Service is hierarchically organized into four levels – the national level, the regional level, the national forest level, and the ranger district level. At the national level, the Chief of the Forest Service provides broad policy and direction for the agency. At the regional level, the regional forester coordinates activities between national forests and provides guidance for forest plans. The national forests in Utah are managed under the Intermountain Region (Region 4) with headquarters in Ogden, Utah. At the national forest level, supervisors provide oversight and support to the ranger districts within the forests. Ranger districts are the units that directly manage the national forests because management can widely vary between districts and national forests. Within Utah, there are 29 ranger districts (Figure 2.4; reference Table 8 in Appendix A).

National Park Service – The concept of national parks, or large-scale natural areas preserved for public enjoyment, originated in 1832 when artist George Catlin noted the potential effects of westward expansion on wilderness and wildlife. Catlin's vision, as well as a growing appreciation for nature by the public, encouraged state and federal governments to set aside expanses of spectacular landscapes. The national park idea came to partial fruition when Congress donated Yosemite Valley to California for preservation as a state park (Mackintosh, 1999). Eight years later, in 1872, President Ulysses Grant signed the Yellowstone Bill into law. The Yellowstone Act withdrew more than 2 million acres of the public domain from settlement and designated the Yellowstone country in the Wyoming and Montana territories as a "public park or pleasuring-ground for the benefit and enjoyment of the people." Nearly two decades later, in 1891, Congress established Sequoia and Yosemite National Parks (NPS, 2005).

While the early national parks were being established, separate legislation was being drafted to protect prehistoric features and archeological sites. In 1906, President Theodore Roosevelt passed the Antiquities Act. The Antiquities Act, considered one of the most important and controversial pieces of preservation legislation, allowed presidents of the United States to set aside historic and prehistoric structures, and other objects of historic and scientific interest on public lands as national monuments. The Antiquities Act, with its vaguely defined scope, indicated that national monuments should be confined to the smallest area compatible with the care and management of the objects to be protected. Initially, it was thought that the act would be used to protect small tracts of land surrounding archeological sites; however, much larger areas were designated as national monuments, such as Natural Bridges in San Juan County, because preservation was still largely compatible with congressional expectations (NPS, 2005; Rotham, 1999).

The Interior Department was responsible for managing several national parks and national monuments, but there was no clear standard for managing the system of reserves. The parks and monuments became vulnerable to competing interests. Some utilitarian conservationists favored regulated use, such as the construction of dams for water supply, power, and irrigation, rather than strict preservation of the natural resources. In 1913, Congress permitted the construction of a dam in the Hetch Hetchy Valley in Yosemite. This event underlined some of the institutional problems of the park movement. Consequently, park advocates, including Stephen Mather, complained to the Secretary of the Interior. Mather, a wealthy Chicago businessman and avid outdoorsman, was appointed as an assistant to the Interior Secretary for park matters. Mather and his assistant, Horace Albright, extensively lobbied and campaigned for national parks and emphasized the economic potential of parks as tourist meccas. Congress responded on August 25, 1916, when President

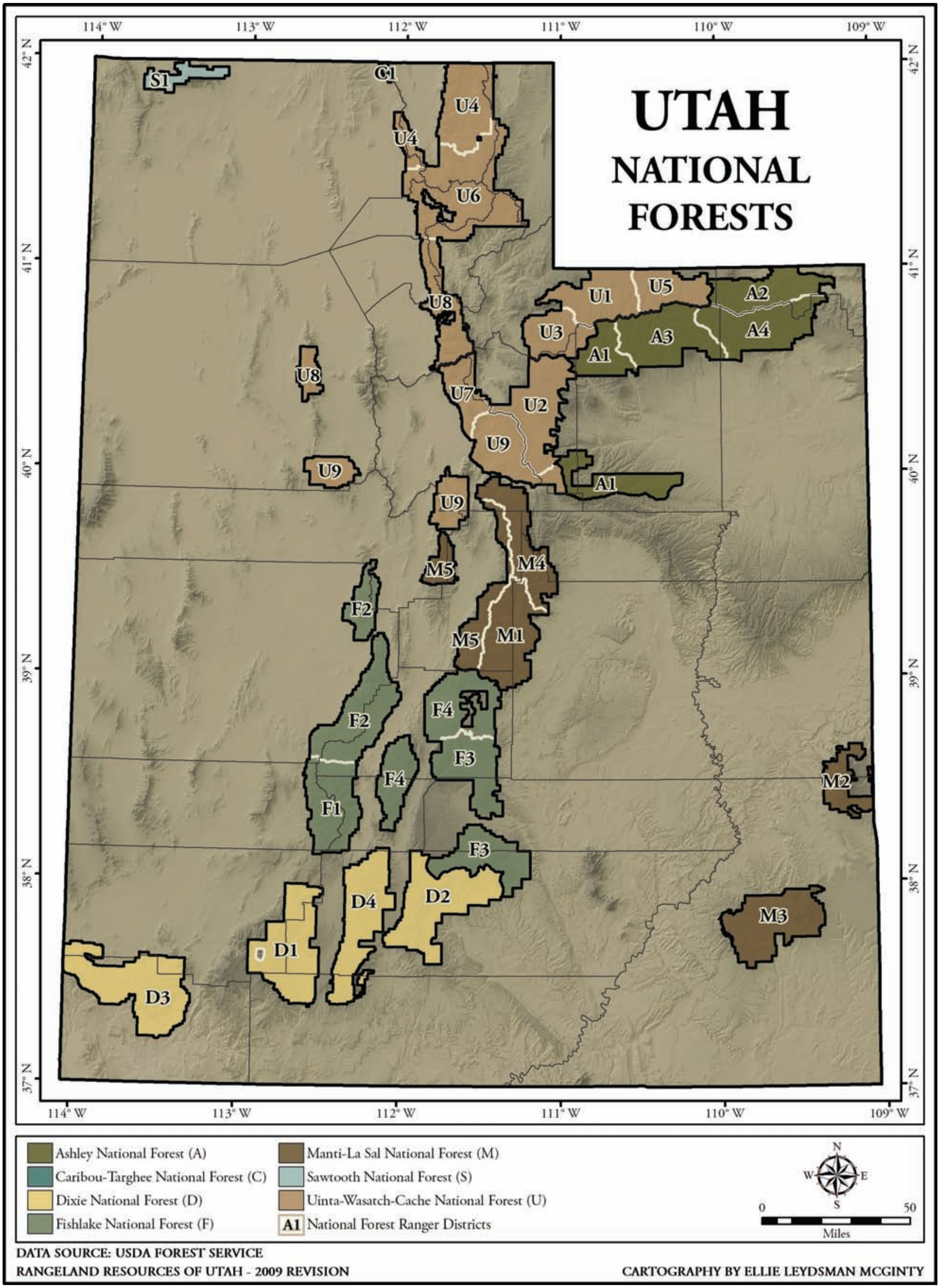


Figure 2.4. National forests and ranger districts in Utah (reference Table 8 in Appendix A).

Woodrow Wilson approved legislation that created the National Park Service within the Department of the Interior (Mackintosh, 1999; NPS, 2005).

The National Park Service has the responsibility of managing over 2 million acres of land in Utah, equating to 3.9 percent of the land area. The agency administers five national parks, six national monuments, one national recreation area, one national historic site (reference Table 8.5.2 in Recreation in Utah section), and portions of four historic trails. The five national parks are Arches National Park, Bryce Canyon National Park, Canyonlands National Park, Capitol Reef National Park, and Zion National Park. Arches National Park was established as a national monument in 1929 to protect the arches, spires, balanced rocks, and sandstone formations. In 1971, Arches National Monument became Arches National Park (NPS, 1999). Bryce Canyon National Park was initially established as a national monument in 1924 after the governor of Utah and the Utah Legislature lobbied for national protection of the area. Attempts to change the status of the national monument to a national park began in 1924; however, it was not until 1928 that Bryce Canyon National Park was established (Scrattish, 1985; NPS, 2005).

Canyonlands National Park, with the support of Arches National Monument Superintendent Bates Wilson, was established in 1964 by President Lyndon Johnson. The park was expanded to its current size in 1971 (NPS, 2006a). Capitol Reef National Park, an especially rugged and spectacular part of the Waterpocket Fold near the Fremont River, was established as a national monument in 1937. With the expansion of the reserve in 1968, considerations to make it a national park were made. After several senate bills were introduced and dropped, Capitol Reef National Monument became Capitol Reef National Park in 1971 (NPS, 2007). Zion National Park, Utah's oldest and most visited national park, was initially established in 1909 as Mukuntuweap National Monument to protect the scenic qualities of the expansive canyon. In 1918, the acting director of the National Park Service changed the name to Zion National Monument. One year later, the reserve was declared a national park. The Kolob section of the park was proclaimed as a separate Zion National Monument in 1937, but it was incorporated into the park in 1956 (NPS, 2006b).

There are seven national monuments in Utah. Six are managed by the National Park Service and one, the Grand Staircase-Escalante National Monument, is managed by the Bureau of Land Management. The six national monuments managed by the National Park Service are Cedar Breaks National Monument, established in 1933; Dinosaur National Monument, established in 1915; Hovenweep National Monument, established in 1923; Natural Bridges National Monument, established in 1908; Rainbow Bridge National Monument, established in 1910; and Timpanogos Cave National Monument, established in 1922.

There are three national recreation areas in Utah. One is managed by the National Park Service, one is managed by the United States Forest Service, and one is managed by the Bureau of Land Management. Glen Canyon National Recreation Area in Utah and Arizona was established in 1972 when Lake Powell and the surrounding area were incorporated as a national site. Flaming Gorge National Recreation Area, managed by the United States Forest Service, was established as part of the Ashley National Forest in 1968 by President Lyndon Johnson (USFS, 2008). Little Sahara National Recreation Area, located in the northeastern part of the Sevier Desert (Juab County), is a managed off-highway vehicle area administered by the Bureau of Land Management (BLM, 2007b).

Golden Spike National Historic Site, the one national historic site in Utah, commemorates the completion of the first transcontinental railroad in the nation. On May 10, 1869, two railroad companies, Union and Central Pacific, joined 1,776 miles of rail at Promontory Summit (NPS, 2009a). In 1957, Golden Spike was authorized by Congress as a National Historic Site under non-federal ownership. In 1965, Congress enlarged the site to encompass over 2,000 acres and it was authorized for federal administration by the National Park Service (Blake, 1994).

The four national historic trails managed by the National Park Service are the California National Historic Trail, Mormon Pioneer National Historic Trail, Old Spanish National Historic Trail, and Pony Express National Historic Trail. The California Trail, bisecting ten midwestern and western states, carried over 250,000 gold-seekers and farmers to California during the 1840s and 1850s. The Mormon Pioneer National Historic Trail, bisecting five midwestern and western states, represents the 70,000 Mormons who traveled from Nauvoo, Illinois, to Salt Lake City, Utah, from 1846 to 1869. The Old Spanish Trail, bisecting six western and southwestern states, represents a network of trading trails linking the markets of Mexico and the United States. The first commercial caravan from Abiquiú, New Mexico, to Los Angeles, California, occurred in 1829. The Pony Express National Historic Trail bisects eight states from Missouri to California. The Pony Express Trail was used to transport the nation's mail in the unprecedented time of 10 days, and it became the most direct means of communication prior to the telegraph (NPS, 2009b).

Department of Defense – Although the Department of Defense was not established until 1949, the preceding military agencies date back to pre-Revolutionary times (US DOD, 2009). During the American Revolution (1775-1783), military affairs were supervised by the Continental Congress, and under the Articles of Confederation, a secretary of war directed defense matters. Formal organization of the United States military occurred in 1789 when the United States Department of War was created. The department became responsible for the operation and maintenance of the Army; however, it was also responsible for naval affairs until the establishment of the United States Department of the Navy in 1798, and for land-based air forces until the creation of the Department of the Air Force in 1947 (Columbia Encyclopedia, 2008).

In 1903, after the Spanish-American War of 1898, the United States Department of War was reorganized and assigned several new functions, including supervision over the newly created National Guard. The National Security Act of 1947, signed by President Harry Truman, reorganized the United States Armed Forces and foreign policy after World War II. The legislation unified military departments by merging the Department of War and the Department of the Navy into the National Military Establishment, headed by the Secretary of Defense. The National Security Act of 1947 also renamed the United States Department of War as the United States Department of the Army and provided for the creation of a separate Department of the Air Force from the existing Army Air Forces (US DOS, 2009). Two years later, on August 10, 1949, the National Security Act was amended to assure that the Departments of Army, Navy, and Air Force were subordinate to the Secretary of Defense. Concurrently, the National Military Establishment was renamed as the United States Department of Defense (Columbia Encyclopedia, 2008). Presently, the Department of Defense includes the Army, Navy, Air Force, Marine Corps, as well as non-combat agencies, such as the National Security Agency and the Defense Intelligence Agency. Additionally, during times of war, the Department of Defense has authority over the Coast Guard (US DOD, 2009).
The Department of Defense administers more than 1.8 million acres of land in Utah, equating to 3.3 percent of the land area. The primary Department of Defense lands in Utah include Camp Williams Military Reservation, Dugway Proving Grounds, Hill Air Force Base, Hill Air Force Range, Tooele Army Depot, and the Utah Test and Training Range. The majority of these military lands were founded during the World War II era (1939-1945); however, Camp Williams and Hill Air Force Base have the longest histories.

Camp Williams, named in honor of Brigadier General W. G. Williams, was established in 1928 as a National Guard training site. During World War II, Camp Williams became a sub-post and training site for Fort Douglas (Alexander and Fish, 1994). Hill Air Force Base dates back to 1934 with an association to the Army Air Mail experiment. In 1935, the Army Air Corps established Ogden, Utah, as a favorable site for its permanent western terminus. In 1939, Congress appropriated funds for the establishment and construction of the Ogden Air Depot. The Ogden Air Depot was named Hill Field in honor of Major Ployer Peter Hill. During World War II, Hill Field served as a central maintenance and supply base, with operations focusing on supporting the war effort. Beginning in 1944, Hill Field began serving as the long-term storage facility for surplus aircraft and support equipment. After the Army Air Corps became the United States Air Force in 1947, Hill Field was designated as Hill Air Force Base (USAF, 2009a).

In terms of military significance, the Utah Test and Training Range prevails. The Utah Test and Training Range is the largest, and one of the few live-fire training ranges in the United States. The testing range, located in northwestern Utah and eastern Nevada, encompasses over 19,000 square miles of restricted airspace with 2,675 square miles of ground space. Missions on the Utah Test and Training Range are coordinated through Hill Air Force Base, and they include open-air training and testing services that support large force training exercises and large footprint weapons testing (USAF, 2009b).

United States Fish and Wildlife Service – The origins of the United States Fish and Wildlife Service date back to 1871 when Congress established the United States Commission on Fish and Fisheries to study the decrease of food fishes within the nation (USFWS, 2008a). Increasing awareness of the importance of fish and wildlife prompted Congress to establish the Division of Economic Ornithology and Mammalogy within the Department of Agriculture. Studies performed by these two agencies revealed that fish and wildlife resources were declining and in need of conservation. As fish and wildlife issues became salient at the turn of the twentieth century, public support increased for more vigorous actions on the part of the government. Advocacy by the American Ornithologists Union, the National Association of Audubon Societies, and the general public encouraged the conservation-oriented President Theodore Roosevelt to establish the first federal bird reservation, Pelican Island in Florida, in 1903 (USFWS, 2009a).

The establishment of Pelican Island initiated a trend of conserving parcels of land in Florida and Louisiana for the protection of various species of nesting birds. As bird reservations increased, the need for sound management was realized. Consequently, the Bureau of Biological Survey was established in the Department of Agriculture, replacing the Division of Economic Ornithology and Mammalogy, with the responsibility of administering the reservations. After the Bureau of Biological Survey was established in 1905, several areas in Washington and California were set aside as federal refuges as a consequence of Pacific sea bird population declines. By 1909, Theodore Roosevelt had issued 51 Executive Orders that established wildlife reservations in 17 states and three territories (USFWS, 2009a).

During the next few decades, the Bureau of Biological Survey experienced several major legislative events. In 1918, the Migratory Bird Treaty Act, which provided for the regulation of migratory bird hunting, was passed. In 1929, the Migratory Bird Conservation Act established a Migratory Bird Conservation Commission to approve areas of land or water for acquisition as reservations for migratory birds. In 1934, funding for the refuge system surfaced when the Migratory Bird Hunting and Conservation Stamp Act was enacted. The act required each waterfowl hunter to possess a valid federal hunting stamp. The receipts from the sale of the stamp provided a continuing source of revenue for the acquisition of migratory bird habitat. Of equal importance, the Fish and Wildlife Coordination Act of 1934 was enacted, which authorized the Secretaries of Agriculture and Commerce to provide assistance to and cooperate with federal and state agencies to protect, rear, stock, and increase the supply of game and fur-bearing animals. A 1958 amendment to the Fish and Wildlife Coordination Act added provisions to recognize the vital contribution of wildlife resources (USFWS, 2009a; USFWS, 2009b).

In 1939, the Bureau of Biological Survey in the Department of Agriculture and the Bureau of Fisheries (formerly the United States Commission of Fish and Fisheries until 1903) in the Department of Commerce were both transferred to the Department of the Interior through a reorganization of the Executive Branch. A subsequent reorganization plan in the Department of the Interior in 1940 consolidated the Bureau of Fisheries and the Bureau of Biological Survey into one agency that was named the United States Fish and Wildlife Service. Years after the United States Fish and Wildlife Service was established, the Fish and Wildlife Act of 1956 was enacted. The act provided a comprehensive national fish and wildlife policy that broadened the authority for the acquisition and development of refuges. Subsequent legislation, including the Refuge Recreation Act of 1962, the National Wildlife Refuge System Administration Act of 1966, and the Endangered Species Act of 1973, provided supplementary funding and accelerated preservation efforts (USFWS, 2009a).

The United States Fish and Wildlife Service administers slightly more than 109 million acres of land in Utah. Although this represents less than 1 percent of the land area in Utah, the preserved land provides habitat for fish and wildlife resources on three national refuges. The three national wildlife refuges are the Bear River Migratory Bird Refuge, Fish Springs National Wildlife Refuge, and Ouray National Wildlife Refuge. Additionally, the United States Fish and Wildlife Service oversees two national fish hatcheries, the Ouray National Fish Hatchery and Jones Hole National Fish Hatchery. They also administer the Vernal Colorado River Fishery Project and the Utah Fish and Wildlife Management Assistance Office (USFWS, 2001).

The Bear River Migratory Bird Refuge, located in Box Elder County, was established in 1928 in response to the substantial reductions in wetland and marsh habitat caused by diversions of water from upstream settlements and farms (USFWS, 2001; USFWS, 2009c). The refuge presently serves a vital role in the Bear River delta ecosystem by protecting, creating, and managing more than 41,000 acres of wetlands. The wetland and marsh habitats of the Bear River delta provide habitat to more than 200 bird species (USFWS, 2009c). Fish Springs National Wildlife Refuge, located at the southern end of the Great Salt Lake Desert in Juab County, was established in 1959 to protect vital habitat for migratory and wintering birds. The nearly 18,000 acre refuge is supplied by five primary springs and several small springs and seeps (USFWS, 2001; USFWS, 2007). Ouray National Wildlife Refuge, located in central Uintah County, was established in 1960 on lands purchased by the United States Fish and Wildlife Service with revenue from the sale of Migratory Bird Hunting and Conservation Stamps. The refuge covers nearly 12,000 acres of habitat as well as 12 miles of the Green River for migrating and breeding waterfowl (USFWS, 2001; USFWS, 2008b).

STATE LANDS

Utah School and Institutional Trust Lands

Administration – The Utah School and Institutional Trust Lands Administration was established by the Utah Legislature in 1994 as an independent agency of the state government to manage lands granted to the state of Utah by the United States following statehood (SITLA, 2008a). Following statehood in 1896, state lands were managed by the State Board of Land Commissioners, a board of elected officials, including the Governor, the Secretary of State, the Attorney General, and two resident commissioners appointed by the Governor. In 1931, management of state lands included three gubernatorial-appointed citizen land commissioners (SITLA, 2008b). In 1969, the Utah legislature established the Division of State Lands with an advisory policy board, consisting of seven members, one of which had to be trained in forestry and fire prevention (UDARS, 2009a).

By 1988, state lands and forestry functions were merged and renamed the Division of State Lands and Forestry. The Division of State Lands and Forestry administered trust lands, sovereign lands, and the state forestry program, and the board consisted of 11 members, including one beneficiary representative. In the early 1990s, it was realized that decades of unimpressive administration had resulted in low total trust assets, and a new organization was essential to improving the trend of trust land revenues. Accordingly, an independent agency, the Utah School and Institutional Trust Lands Administration, was established in 1994 with a seven-member board appointed by the Governor (SITLA, 2008b).

The federal government granted sections 2, 16, 32, and 36 of each township to the state to be managed in trust to provide financial support for education and other beneficiary institutions. Each section is approximately 640 acres, and 36 sections constitute one township. Prior to 1896, the federal government granted other western states two sections, sections 16 and 36, for the support of common schools. However, Arizona, New Mexico, and Utah were granted an additional two sections, sections 2 and 32. In the case that either of these sections was already occupied, the states were given the opportunity to select other lands. This system of land transfer resulted in a scattered checkerboard pattern of state trust land (SITLA, 2008b).
At statehood, trust lands totaled over 7.4 million acres. Since 1896, more than one-half of the original trust lands have been sold. The majority was sold during the first 35 years following statehood; however, land sales and investments continue today to provide revenue for Utah schools and 11 other beneficiaries. Presently, the Utah School and Institutional Trust Lands Administration manages over 3.4 million acres of land, or 6.3 percent of the land area. Additionally, the agency administers another million acres of subsurface or mineral lands (SITLA, 2008b).

Since the Utah School and Institutional Trust Lands Administration is legally obligated to optimize financial return for schools and beneficiaries, they engage in land sales, land leases, and investments. Mineral land leases and developed land sales have recently yielded the highest returns. In 2008, 50.6 percent of the annual revenue came from oil and gas, 16.6 percent from development sales, and 12.3 percent from coal and other minerals (SITLA, 2008a). Other profits may result from grazing and forestry leases, as nearly 3 million acres of trust land are permitted for grazing purposes and 250,000 acres are managed as forests (SITLA, 2008b).

In addition to engaging in land sales, land leases, and investments, the Utah School and Institutional Trust Lands Administration organizes land exchanges and conservation sales. Historically, block trades were made as military reservations, national monuments, and national parks were established. Currently, land exchanges and conservation sales are created to preserve scenic and environmentally sensitive trust lands from future transactions. Recently, the Trust Lands Administration and the Bureau of Land Management coordinated an exchange in Iron County that transferred 1,000 acres of trust land inside the Three Peaks Recreation Area west of Cedar City into public ownership. In return, the Trust Lands Administration received 330 acres of federal land suitable for future development outside the recreation area (SITLA, 2008a).

Utah Division of Forestry, Fire, and State Lands – The Utah Division of Forestry, Fire, and State Lands is an agency within the Utah Department of Natural Resources that is responsible for managing state sovereign lands, as well as directing programs that maintain healthy forests and provide wildfire assistance (UDNR, 2009a). The Division of Forestry, Fire, and State Lands traces its origins back to statehood when the State Board of Land Commissioners was created in 1896 to manage state lands. For nearly a century, state sovereign lands were managed in conjunction with state trust lands (UDARS, 2009b). Both sovereign and trust lands were managed by the State Board of Land Commissioners (1896-1969), the Division of State Lands (1969-1988), and the Division of State Lands and Forestry (1988-1993). In 1994, the state legislature separated the Division of State Lands and Forestry into two organizations. The Utah School and Institutional Trust Lands Administration was established as an independent agency to manage trust lands, while the renamed Division of Sovereign Lands and Forestry remained in the Department of Natural Resources to manage state sovereign lands and forestry programs. In 1995, the agency was once again renamed to the Utah Division of Forestry, Fire, and State Lands (UDARS, 2009b).

The Utah Division of Forestry, Fire, and State Lands has a multi-objective mission that includes the management of state sovereign lands (UDFFSL, 2009). State sovereign lands in Utah are classified as the lands that lie below the ordinary high-water mark of navigable bodies of water. These include Utah Lake, Great Salt Lake, Bear Lake, the Jordan River, and portions of the Green River, Colorado River, and Bear River. They encompass over 1.45 million acres of land and cover 2.7 percent of the land area in Utah. The framework for sovereign land management is found in the Utah Constitution, state statute, and administrative rule. The Utah Constitution accepts sovereign lands to be held in trust for the people, under the public trust doctrine, and managed for the purposes for which the lands were acquired. Presently, the Division of Forestry, Fire, and State Lands manages state sovereign land using multiple-use and sustained-yield principles (ULC, 2009).

Utah Division of Wildlife Resources – The Utah Division of Wildlife Resources is an agency within the Department of Natural Resources that is responsible for sustaining wildlife populations, improving wildlife habitat, and conserving sensitive species (UDNR, 2009b). Although formal agencies were not established to address wildlife issues until statehood in 1896, provisions for wildlife protection were established by the Utah territorial legislature. In 1853, the legislative assembly passed an act to prevent the needless destruction of fish. In 1874, An Act for the Protection of Fowl and Fish further defined fish provisions and provided for the protection of game and song birds. In 1882, $200 were allocated to Joseph Barfoot to serve as the territorial fish commissioner, and by 1887, $500 were apportioned to Milton Musser to function as a territorial fish and game commissioner (Rawley and Rawley, 1967).

At the time of statehood in 1896, the first legislature of Utah founded a Committee of Fish and Game and revised the territorial legislation pertaining to fish and game. The revisions provided for a State Fish and Game Warden, who was appointed by the Governor with the approval of the Senate. The first warden, John Sharp, was given jurisdiction over all state lands that concerned fish and wildlife. In 1899, the state legislature changed the name of the warden to the State Fish and Game Commissioner. During the next few decades, hunting and fishing licenses were instituted. In 1909, resident licenses were $1.25 and nonresident fees were $5.00 (Rawley and Rawley, 1967).

In 1919, under the administration of Governor Simon Bamburger, the state legislature made provisions for the establishment of five game preserves, and by 1921, the state had eight fish hatcheries. The State Fish and Game Commissioner supervised several full-time wardens and employees to act as law enforcement and to support wildlife propagation. Fish and Game personnel steadily increased as new committees were established and research was initiated. During the 1930s, the State Fish and Game Commissioner coordinated with New Deal agencies, such as the Civilian Conservation Corps and the Works Progress Administration, to support and expand fish and game resources in Utah (Rawley and Rawley, 1967).

In 1941, the state legislature reorganized the fish and game agency and replaced the State Fish and Game Commissioner with a three-man commission, subsequently establishing the Department of Fish and Game. The following year, the Fish and Game Commission within the Department consisted of five men. Nearly two decades later, in 1962, the department had divided the state into five regions for administrative purposes. Regional offices were established in Ogden (Northern Region), Provo (Central Region), Cedar City (Southern Region), Price (Southeastern Region), and Vernal (Northeastern Region). The regional offices progressively became more valuable as population and demands increased (Rawley and Rawley, 1967).

With the passage of the Utah Natural Resources Act of 1967, the Department of Natural Resources was founded with the goals of establishing lines of administrative responsibility and increasing administrative efficiency. Under this act, seven newly created divisions were established, including the Division of Fish and Game. Under this reorganization, the name of the commission was changed to the Board of Fish and Game, and a coordinating council of seven members was appointed to coordinate cooperation among the boards and divisions (Rawley and Rawley, 1967). A subsequent reorganization in 1971 resulted in the renaming of the Division of Fish and Game to the Utah Division of Wildlife Resources (UDARS, 2009c).

The Utah Division of Wildlife Resources serves the people of Utah as a trustee of wildlife resources in Utah by managing wildlife habitat programs, administering hunting and fishing licenses, implementing species recovery programs, enhancing wildlife habitat, coordinating restoration projects, and developing community fisheries (UDWR, 2009). The Utah Division of Wildlife Resources currently administers over 470,000 acres of state wildlife reserves. The agency has also been instrumental in coordinating efforts with private landowners to establish cooperative wildlife management units. The Cooperative Wildlife Management Program, comprising more than 2 million acres of land in Utah, provides landowners with an economic incentive to maintain range and forest lands as wildlife habitat (UDWR, 2009).

Utah State Parks and Recreation – The Utah Division of State Parks and Recreation is an agency within the Department of Natural Resources that is responsible for managing state parks and museums throughout Utah. Utah State Parks and Recreation is one of the younger state agencies. In fact, Utah was the last state to establish a parks and recreation program. In 1957, the Utah State Parks and Recreation Commission was created through the passage of a senate bill. Once established, the commission quickly inventoried potential state parks, reporting and recommending 118 state park areas to the state legislature in 1959 (Powell, 1996).

Wasatch Mountain State Park was given priority for funding. The proposed park was to encompass 25,800 acres. More than 1,200 acres was already owned by the state, but 560 acres needed to be acquired from the Bureau of Land Management, and the remaining 23,960 acres needed to be purchased from private land owners (Powell, 1996). The state legislature also designated the old Utah State Prison site in Sugar House, This is the Place Monument, Camp Floyd, and the Territorial Statehouse as state parks. The old Utah State Prison site was later excluded when it became Sugar House Park (UDARS, 2009d).

In 1966, Governor Calvin Rampton grouped the Utah State Department of Fish and Game with the State Park and Recreation Commission and appointed F. C. Koziol as the director. This reorganization lasted for one year until the passage of the Utah Natural Resources Act in 1967. With the establishment of the Department of Natural Resources, the Utah Division of Parks and Recreation was founded. Since that time, the state park system has expanded into an array of scenic and natural areas, cultural and historic sites, and water recreation locales (UDARS, 2009d). Presently, the Utah Division of State Parks and Recreation manages 43 state parks and museums on more than 119,000 acres of land (reference Table 8.5.1 in Recreation in Utah section). Utah State Parks and Recreation was named among the top three state park systems in the nation for excellence in public and private partnerships, long-range planning, resource management, preservation, and technological integration (UDNR, 2009c).

PRIVATE LANDS

Utah was the last area in the continental United States where the public domain was opened to private ownership. The early citizens of Utah were not permitted the benefits of land disposal laws largely because disagreements between Mormon Church doctrine, laws of the United States, and the territorial legislature generated unsettled church-state conflict. The Preemption Act of 1830, which allowed settlers to buy up to 160 acres of land for $1.25 per acre, and the Homestead Act of 1862, which granted 160 acres to those willing to settle the American Frontier, did not become applicable in the Utah Territory until January 1869 when the first Utah land office was opened. Although many settlers previously had squatter claims on land under the authority of the territorial legislature, land was not recognized under national law as privately owned until the land office confirmed titles. During the first 6 months of administration, the land office validated titles to 148,803 acres of land granted under the Preemption Act and the Homestead Act (Anderson, 1989).

With the completion of the transcontinental railroad in 1869, distant markets became more accessible in Utah. Consequently, many Utah settlers ventured into novel business enterprises, such as the industry of livestock production. The expansion of livestock businesses in Utah necessitated additional land transfers to private entities. Many transfers were honored under the Preemption and Homestead Acts; however, additional legislation stimulated land transfers from the public domain to private landowners. The Timber Culture Act of 1873 granted 160 acres to settlers free of charge with the stipulation that part of the land be planted with trees. The Desert Land Act of 1877 allowed settlers to purchase up to 640 acres of land for $1.25 per acre, provided that some irrigation structures were developed. The Stock Raising Homestead Act of 1916 permitted the acquisition of 640 acres of public lands that were deemed unsuitable for all uses other than livestock grazing (Anderson, 1989).

Private titleholders are collectively the second largest landowner in the state of Utah. Private lands comprise over 11.4 million acres of land. This equates to 21.1 percent of the land area. The majority of private lands in Utah are located in northern and central Utah in the fertile valleys and upland benches. Although early federal legislation played an integral role in defining the patterns and distribution of private land in the state, the transfer of state trust land has also contributed to private ownership patterns. In fact, approximately 30 percent of all private lands in Utah were originally state trust lands (SITLA, 2008a).

TRIBAL LANDS

Five major Native American Indian tribes continue to inhabit Utah despite the considerable conflicts they had with Euro-American settlers in the mid-nineteenth century. Through treaties, court decision, and federal statutes, the Ute, Navajo (Dine), Paiute, Goshute, and Shoshoni tribes, in partnership with Bureau of Indian Affairs, administer more than 2.45 million acres of tribal trust lands throughout Utah. This equates to 4.5 percent of the land area. Ute tribal trust lands include the Uintah and Ouray Reservation and White Mesa Ute Reservation. Navajo trust lands include the Navajo Nation Reservation. Paiute trust lands include the Shivwits Band, Indian Peaks Band, Kanosh Band, Koosharem Band, and Cedar Band reservations. Goshute trust lands include the Skull Valley Band Reservation and the Confederated Tribes of the Goshute Reservation. Shoshoni trust lands include the Northwestern Band of the Shoshoni Nation Reservation.

The Uintah and Ouray Reservation, located in Duchesne, Uintah, and Grand counties, was established in 1861 when President Abraham Lincoln set aside the Uintah Valley Reservation under the Treaty of Spanish Fork. The Treaty of Spanish Fork was established in response to several armed conflicts and competition for resources between Mormon settlers and the Ute tribes. Resistance to leave Utah Valley and to relocate to the reservation in the Uintah Basin led to a series of attacks and subsistence raids known as the Black Hawk War (1863-1868). By 1869, the Utes were starving and suffering from retaliation. Consequently, they turned to civil leader Tabby-to-kwana, who directed them to the reservation. In 1881, another reservation, the Uncompahgre Reservation, was established adjacent to the Uintah Reservation and two other bands, the Yamparka and Parianuc (White River) Utes, were removed from Colorado and taken to the Uintah Basin. In 1886, the Uintah and Ouray agencies and reservations were consolidated into the Uintah-Ouray Reservation (Lewis, 1994b).

The White Mesa Ute Reservation, located near Blanding in San Juan County, is a sub-agency reservation of the Ute Mountain Ute Tribe in Towaoc, Colorado. The White Mesa Ute Reservation was established after the Utah Utes, Southern Utes, and Ute Mountain Utes received monetary recompense during the 1950s. The Southern Utes living in Blanding requested better lands for farming and livestock production, and eventually, land located 11 miles south of Blanding, now known as White Mesa, was granted to the Utes for settlement. The location was close enough to Blanding for employment resources, yet distant enough to foster a sense of individual identity (McPherson and Yazzie, 2009). In 1978, the White Mesa Ute Council was established with the responsibility of managing educational and self-sufficiency programs (UDIA, 2009a).

The Navajo Nation Reservation, located in San Juan County, was established with the Treaty of 1868. The treaty was incited after decades of conflict and suffering. Residents of Mormon colonies in southwestern Utah and settlers in New Mexico and Arizona reacted against the Navajo by sending military expeditions to halt and control them. In 1862, the military directed Christopher Houston "Kit" Carson to proceed to the Navajo territory to persuade the Navajos to surrender. In 1864, over 8,000 Navajos were forced to take the Long Walk to Bosque Redondo (Fort Sumner) in New Mexico. For four years, the Navajo were confined to a concentration camp. With the Treaty of 1868, the Navajo were permitted to return to Utah and Arizona; albeit, the reservation was one-fourth the size of the original territory they had used (McPherson, 1994). Presently, the Utah Navajo (Dine) are served by the Navajo Nation, headquartered in Window Rock, Arizona, and the Navajo-Utah Commission Office in Montezuma Creek, Utah (UDIA, 2009b).

The Paiute Indians in southern Utah consist of five bands, including the Shivwits, Indian Peaks, Kanosh, Koosharem, and Cedar. Although significant conflict did not occur between settlers and the Paiutes, sustained contact with Euro-Americans during the mid-nineteenth century resulted in outbreaks of disease, and introduced agricultural practices made it difficult for Paiutes to continue their traditional lifestyle. Although the Paiutes and the federal government signed a treaty in 1865, the first reservation, the Shivwits near St. George, was not established until 1891. Other small reservations were established by executive orders, including Indian Peaks in 1915; Koosharem in 1928; and Kanosh in 1929 (Holt, 1994; UDIA, 2009b).

In 1927, a Paiute agency was established in Cedar City by the Bureau of Indian Affairs, and in 1935, the Shivwits and Kanosh Paiutes accepted the Wheeler-Howard Act, also known as the Indian Reorganization Act. This legislation encouraged self-governance and the protection of land rights. During the 1950s, the Utah Paiutes became victims of the termination policy of Congress, which eliminated federal tax protection, health education benefits, and agricultural assistance to Native American Indian tribes. As a result, Paiutes became stricken with poverty. In 1980, through efforts of Utah Senator Orrin Hatch, President Jimmy Carter signed legislation that restored federal recognition of the Paiutes. In 1984, the Paiutes received nearly 5,000 acres of BLM land scattered throughout southwestern Utah (Holt, 1994; UDIA, 2009b).

There are two bands of the Goshute Nation in Utah, including the Skull Valley Band of Goshute and the Confederated Tribes of the Goshute. A treaty between the Goshutes and the federal government was signed in 1863 after disputes led to the death of many Goshutes. The treaty was not one of land cession or financial support, but it declared the end to all hostile actions. By 1869, the majority of the Goshutes had abandoned many of their traditional ways and had settled on farms at Deep Creek and Skull Valley. During the first decade of the twentieth century, the federal government established two reservations for the Goshutes. The larger of the two is located on the Utah-Nevada border (White Pine County, Nevada, and Juab County, Utah) at the base of the Deep Creek Mountains, while the smaller reservation is located in Skull Valley in Tooele County (Defa, 1994; UDIA, 2009b).

The Northwestern Band of the Shoshoni signed a treaty with the government in 1863 after the Bear River Massacre. The Bear River Massacre, a violent conflict between a military unit directed by Colonel Patrick Edward Conner and the Shoshoni Indians, resulted in the death of Chief Bear Hunter and approximately 250 members of his tribe. The remaining tribal members under Chief Sagwitch and the chiefs of nine other bands signed the Treaty of Box Elder in Brigham City. After the Treaty of Box Elder was signed, government officials encouraged all of the Northwestern Shoshoni to move to the Fort Hall Indian Reservation in Idaho. Eventually, the Northwestern Shoshoni left the mouth of the Bear River near Corinne, Utah, and relocated to Fort Hall (Madsen, 1994b). In 1980, the Northwestern Band of the Shoshoni became recognized by the federal government, and offices were established in Brigham City, Utah, and Blackfoot, Idaho (UDIA, 2009b).

PHYSIOGRAPHY OF UTAH

Ellie I. Leydsman McGinty
Christopher M. McGinty

The state of Utah is centrally located in the Intermountain West, spanning the ranges of 109° West and 114° West longitude and 37° North and 42° North latitude. The state is approximately 84,868 square miles in size and has 29 counties, with San Juan, Tooele, Millard, and Box Elder counties being the largest. Elevations in Utah range from 2,178 feet at Beaver Dam Wash in the southwestern corner of the state to 13,528 feet at the summit of King's Peak in the Uinta Mountains (Figure 3.1). The Uinta Mountains have several peaks that exceed 13,000 feet; the La Sal, Tushar, and Deep Creek Mountains have peaks that exceed 12,000 feet; and the Wasatch Mountains have numerous peaks that exceed 11,000 feet. The highest peak in the Wasatch Mountains is Mount Nebo at 11,877 feet (Fisher, 1994).

Three primary physiographic regions, each with unique topographic, geologic, and geomorphic characteristics, extend into Utah. They include the Colorado Plateau, the Basin and Range, and the Middle Rocky Mountains. Additionally, small portions of the Columbia Plateau and the Wyoming Basin extend into Utah. The three primary regions substantially differ, yielding diverse, dynamic, and impressive landscapes. Processes of erosion dominate the Colorado Plateau; sedimentation dominates the Basin and Range; and faulting, folding, and glaciation dominate the Middle Rocky Mountains (Atwood, 1994).

COLORADO PLATEAU

The Colorado Plateau is a broad area of regional uplift that covers southern and eastern Utah, western Colorado, northwestern New Mexico, and northern Arizona. The region is characterized by a variety of landforms composed of flat-lying sedimentary rocks. Beginning nearly 10 million years ago, the geologic formations were uplifted and the erosive power of water sculpted outstanding plateaus, buttes, mesas, deeply incised canyons, and river gorges that presently range from 5,000 to 11,000 feet in elevation (Milligan, 2000; Bauman, 1994). The Colorado Plateau holds some of the most spectacular landscapes, including Canyonlands, Arches, Capitol Reef, Zion, Grand Canyon, Natural Bridges, Kodochrome Basin, and Glen Canyon National Recreation Area, and it has one of the largest deposits of hydrocarbons, such as coal, oil, and tar sands, in North America (Bauman, 1994).

The Colorado Plateau is divided into six subprovinces, including the High Plateaus, Uinta Basin, Canyonlands, Navajo, Grand Canyon, and Datil sections. In Utah, the High Plateaus, Uinta Basin, and Canyonlands sections dominate. Additionally, isolated mountains of the Southern Rockies, including the La Sal and Abajo Mountains, protrude from the dry expanses of the Colorado Plateau in Utah.

The High Plateaus are a series of gently rolling plateaus consisting of nearly horizontal sedimentary formations, which in some areas are surfaced by lava flows and glacial deposits. The individual plateaus, such as the Awapa, Aquarius, and Paunsaugunt Plateaus, are separated by north-south trending faults and valleys. The valley margins are often defined by colorful topography, such as that found in Bryce Canyon and Cedar Breaks. The southern margin of the section is defined by a series of impressive cliffs collectively known as the Grand Staircase. They include the Chocolate Cliffs, Vermillion Cliffs, White Cliffs, Gray Cliffs, Pink Cliffs, and Black Cliffs (Murphy, 1989).

The Uinta Basin is located in the northeast corner of the state and south of the Uinta Mountains. The southern rim of the basin is formed by the Tavaputs Plateau, Roan Cliffs, and Book Cliffs; and the western rim is formed by the Wasatch Mountains. Elevations at the top of the Roan Cliffs at the southern rim are over 9,000 feet, while the basin floor near Vernal is approximately 5,000 feet (Fuller, 1994). Although the central portion of the Uinta Basin is gently rolling, there are areas of deeply incised ravines. The Green River and its tributaries have eroded many spectacular canyons, such as Desolation Canyon (Murphy, 1989).

The Canyonlands section of the Colorado Plateau is located in the southeastern quarter of the state. The Kaiparowits Plateau in south-central Utah is the transitional zone between the Canyonlands and High Plateaus sections to the west, while the Book Cliffs and Roan Cliffs form the transitional zone between the Canyonlands and Uinta Basin sections to the north. Mancos shale lowlands, a region of fairly level topography, have developed at the base of the Book Cliffs and High Plateaus. The Canyonlands section has been profoundly sculptured by the Colorado River and its tributaries, resulting in deep, sheer-walled canyons, plateaus, mesas, buttes, and badlands. Delicate rock forms, such as tall pinnacles, deep alcoves, natural

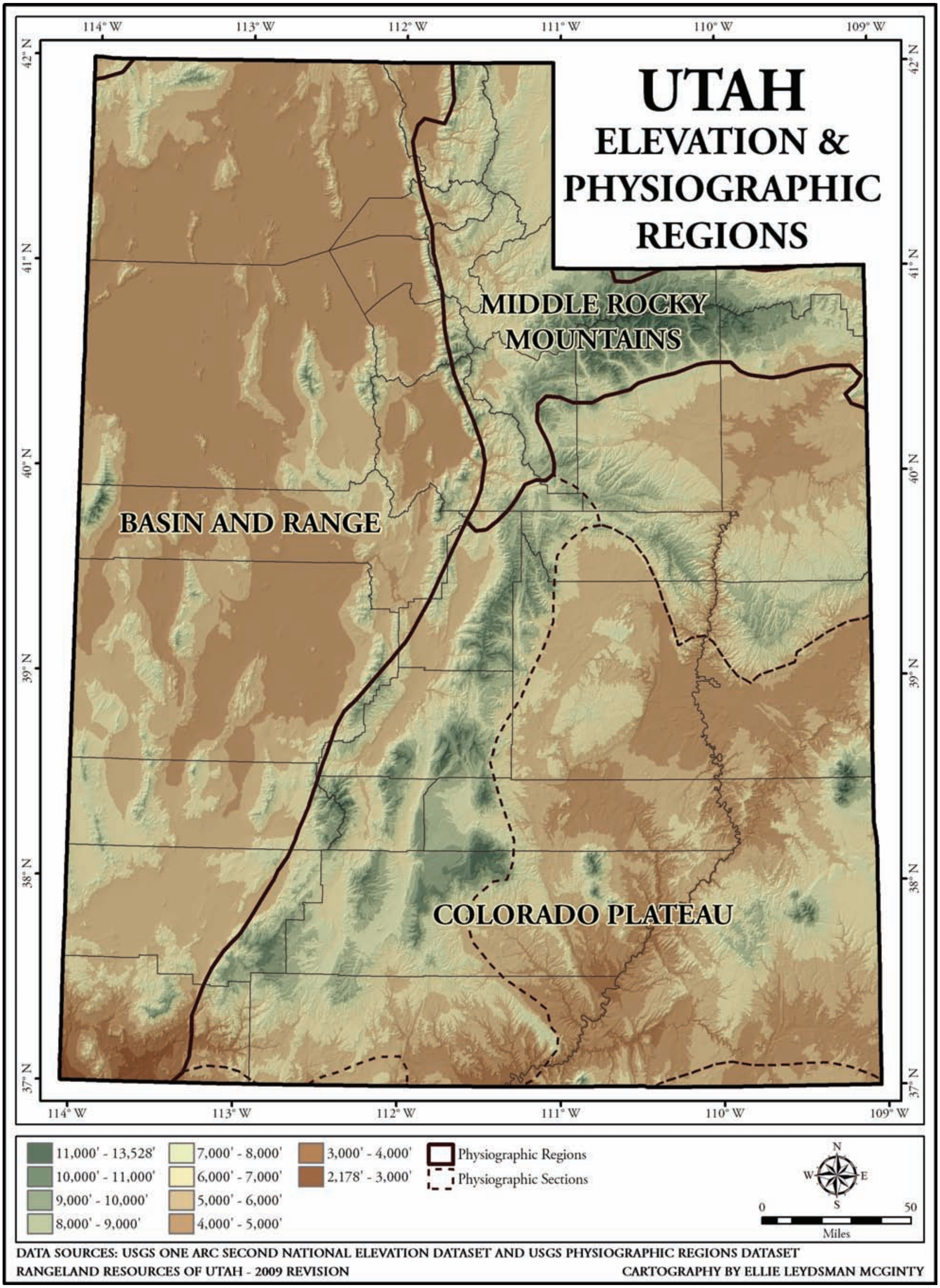


Figure 3.1. Elevation and physiographic regions of Utah.

bridges, and arches, are abundant. These features, when combined with outstanding colors, produce some of the most rugged and scenic topography in the United States (Murphy, 1989).

Although the Colorado Plateau region is characterized by a variety of landforms composed of flat-lying sedimentary rocks, the Canyonlands section has some exceptions. Within the Canyonlands section, a series of steep, rugged, and isolated mountains occur. The Abajo and La Sal Mountains, an isolated subset of the Southern Rockies, as well as the Henry Mountains, are highlands formed by igneous intrusions. The Waterpocket Fold and the San Rafael Swell were formed from the arching and folding of geologic substrates (Milligan, 2000; Murphy, 1989).

BASIN AND RANGE

The Basin and Range region is a large province that includes a large portion of the southwestern United States and northwestern Mexico. The region is bound by the Sierra Nevada Mountains and the Cascade Range on the west, the Columbia Plateau on the north, and the Rocky Mountains and Colorado Plateau on the east. The region is characterized by numerous north-south oriented, fault-tilted mountain ranges that are separated by intervening, broad, sediment-filled basins. Two additional landforms are typical of the Basin and Range region, including playas and alluvial fans. Playas are undrained mud or salt flats that are composed of layers of sediments. Alluvial fans are erosional deposits of sand and gravel that typically occur at canyon mouths (Peterson, 1994). Many of the basins within the region were also modified by shorelines and sediments of inland lakes that intermittently covered the valley floors. The most notable of these was Lake Bonneville (Milligan, 2000).

The Basin and Range is subdivided into five regions, including the Great Basin, Sonoran Desert, Salton Trough, Mexican Highland, and Sacramento sections. The Great Basin section, the northern part of the Basin and Range region, is the only one to occur in Utah. The Great Basin is a large arid region of the western United States that covers most of Nevada and nearly half of Utah, as well as parts of California, Idaho, and Oregon. The region extends from the Sierra Nevada Mountains to the Wasatch Mountains, and is most commonly defined as an endorheic, or internally-drained, basin. As with the Basin and Range region, mountain ranges within the Great Basin were formed by faulting and subsequent erosion. In some areas, the mountain ranges have been so extensively reduced by erosion, and buried by the deposition of material, that only small remnants are visible above coalescing alluvial fans (Murphy, 1989).

A large portion of the Great Basin in Utah is called the Bonneville Basin. The Bonneville Basin and associated Bonneville Salt Flats were formed through the recession and evaporation of the Pleistocene-era Lake Bonneville (Hallaran, 1994). The lowest elevation within the Great Basin occurs within the Bonneville Basin and is covered by the Great Salt Lake. The surface of the Great Salt Lake is approximately 4,200 feet. The elevations of other major features in the Great Basin include the Sevier Basin at approximately 4,700 feet and the Escalante Basin at approximately 4,900 feet (Fisher, 1994).

MIDDLE ROCKY MOUNTAINS

The Middle Rocky Mountains are located in Montana, Wyoming, Idaho, and Utah, and are bound by the Basin and Range and Columbia Plateau to the west and by the Wyoming Basin and Colorado Plateau to the east. In Utah, the Middle Rocky Mountains are located in north and northeastern Utah and consist of the north-south trending Wasatch Range and the east-west trending Uinta Mountains. The region is characterized by mountainous terrain, stream valleys, alluvial basins, sharp ridge lines, U-shaped valleys, glacial lakes, and glacial moraines. Since settlement, the Middle Rocky Mountain region has been valuable to the state of Utah for water, timber, mineral, and recreation resources (Milligan, 2000; Fisher, 1994).

The Wasatch Mountains are located in northern and north-central Utah, and extend from the Bear River Range on the Utah-Idaho border in the north to Salt Creek Canyon near Nephi in the south. The Wasatch Mountains are the transition zone between the Basin and Range region to the west and Colorado Plateau to the south and southeast. The mountains consist of fault-block ranges that are structurally similar to the mountains in the Basin and Range (Fisher, 1994). The western flanks of the ranges are steep and relatively straight as a result of displacement along the extensive and active Wasatch Fault. During the Pleistocene, higher elevations of the Wasatch Mountains were covered in glaciers, and as the climate warmed, glacial erosion created many features, including cirques and moraines (Murphy, 1989). During the time of extensive glaciation, the recession of Lake Bonneville formed a series of benches along the western mountain fronts, creating the Bonneville, Provo, and Gilbert shorelines (Atwood, 1994).

The Uinta Mountains are located in the northeastern portion of Utah and consist of a single range of peaks extending in a general east-west orientation. The range is approximately 30 miles wide and 150 miles long and extends from Heber Valley on the west to Cross Mountains in Colorado on the east (Fuller, 1994). The range is bordered by the Uinta Basin to the south and the Wyoming Basin to the north. The mountains gradually rise above the plateaus to the north and south, and reach their maximum elevations in the central portion (Atwood, 1909). Unlike the fault-block mountains of the Basin and Range and the Wasatch Mountains, the Uinta Range is a folded anticline. The broad, massive range was created by anticlinal uplifting, with sedimentary units outcropping on the flanks. Glacial features, such as horns, arêtes, cirques, and glacial troughs, dominate the present landscape. The deposition of ice and glacial-melt water filled many U-shaped valleys with moraine (glacial debris), lined them with lateral moraines, and left terminal moraines that have often formed natural dams, creating over a thousand small lakes (Murphy, 1989).

PHYSIOGRAPHIC REGIONS VERSUS ECOREGIONS

The physiographic regions of the western United States were initially defined by Nevin M. Fenneman in 1931. A revision of Fenneman's three-tiered classification of the United States was published by the United States Geological Survey in 1946 that delineated eight major divisions, 25 physiographic provinces, or regions, and 86 sections within the coterminous United States. Physiographic, or geomorphic, regions were defined based on terrain texture, rock type, and geologic structure and history. The revised map produced by the United States Geological Survey was automated from Fenneman's 1:7,000,000-scale map (USGS, 2009).

Beginning in 1976, more detailed and holistic regional classifications were being developed. Robert G. Bailey developed Bailey's ecoregions for the United States Forest Service in response to increased involvement by public land management agencies in regional and long-range planning. Bailey divided North America into a hierarchy of domains, divisions, provinces, and sections based on topography, climate, and vegetation (Bailey, 1995).

In 1987, James M. Omernik compiled a national ecological classification, recognizing the importance of considering physical and biotic characteristics. Omernik, in cooperation with the United States Environmental Protection Agency, has developed national datasets of ecological regions, or ecoregions, in the United States to improve environmental resource research, assessment, monitoring, and management. Omernik's ecoregions denote areas of general similarity and incorporate physiography, geology, vegetation, climate, soils, land use, wildlife, and hydrology (US EPA, 2009). A Roman numeral scheme has been adopted for four levels of ecological regions. Level I is the coarsest level, dividing North America into 15 ecological regions. Level II divides the continent into 52 regions. Level III divides the continental United States into 104 ecoregions. Level IV ecological regions are further subdivisions of Level III ecoregions, and they are still being delineated in some areas of the United States. In Utah, there are seven Level III ecoregions and 37 Level IV ecoregions (Figure 3.2; Table 1 in Appendix B; reference section on Vegetation of Utah).

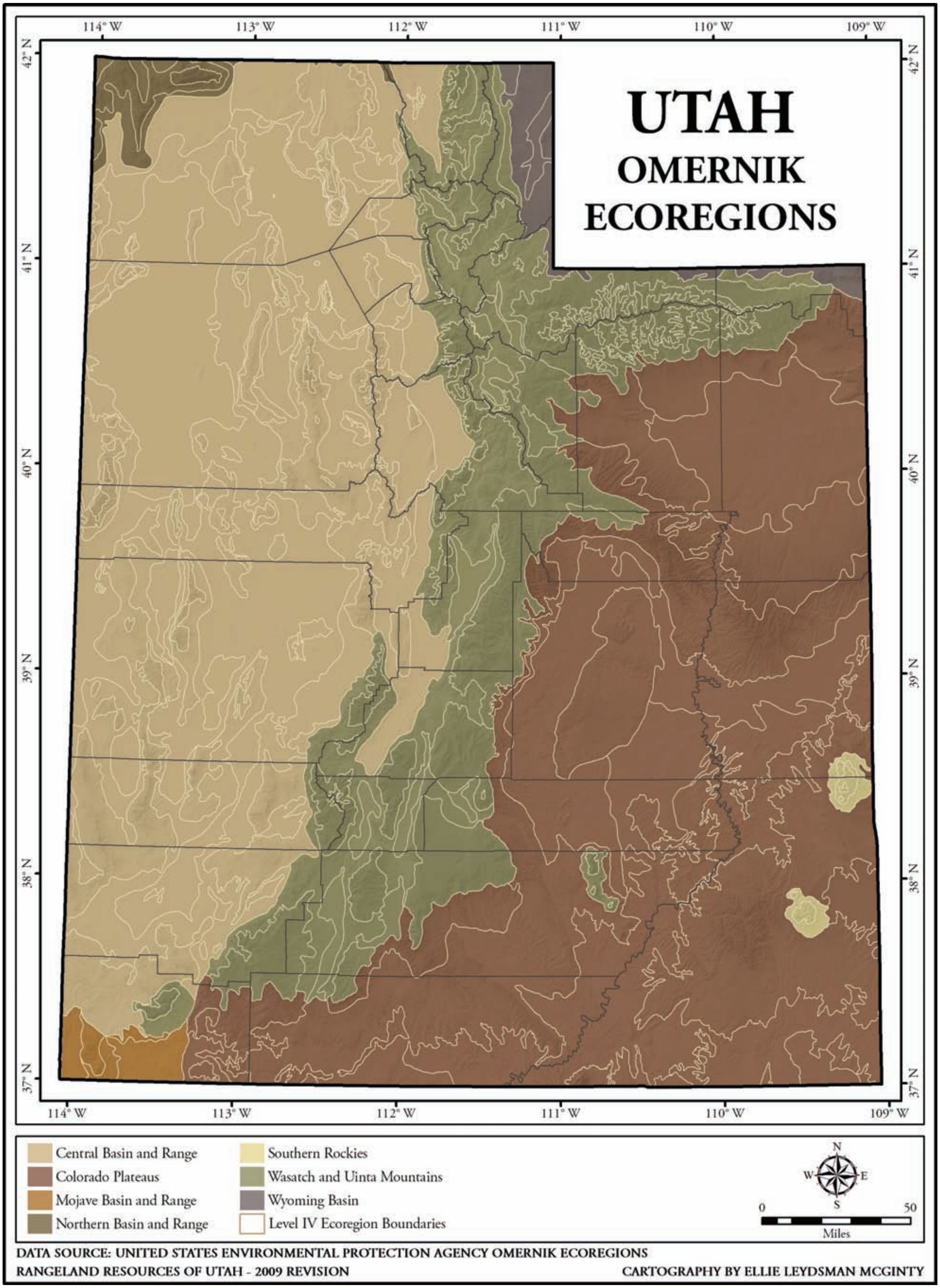


Figure 3.2. Level III and IV Omernik (EPA) Ecoregions for Utah (reference Table 1 in Appendix B).

WATERSHED BASINS OF UTAH

R. Douglas Ramsey
Roger E. Banner
Ellie I. Leydsman McGinty

The USDA Natural Resources Conservation Service (NRCS) and the United States Geological Survey (USGS), as part of a national effort, have generated watershed, or hydrologic, boundaries for the United States. Hydrologic boundaries define the aerial extent of surface water drainage to a point. Hydrologic units, through four levels, were created in the 1970s. Since the 1970s, the USGS developed a hierarchical hydrologic unit code (HUC) for the United States. The hierarchical system divides the country into 21 regions, 222 sub-regions, 352 basins, and 2,149 sub-basins. During the late 1970s, the NRCS initiated a national program to divide the sub-basins into watersheds and sub-watersheds (NRCS, 2009a). Consequently, regions are the largest level, and within regions, there are sub-regions, basins, sub-basins, watersheds, and sub-watersheds.

The state of Utah falls within four specific regions, including: the Great Basin Region, the Upper Colorado Region, the Lower Colorado Region, and the Pacific Northwest Region (Figure 4.1). Within the Great Basin Region in Utah, there are three sub-regions, including: the Escalante Desert-Sevier Lake, the Great Salt Lake, and the Bear River. Within the Upper Colorado Region in Utah, there are seven sub-regions, including: the Colorado Headwaters, Upper Colorado-Dolores, Upper Colorado-Dirty Devil, Great Divide-Upper Green, Lower Green, and White-Yampa. Within the Lower Colorado Region in Utah, there is one sub-region, the Lower Colorado-Lake Mead. Within the Pacific Northwest Region in Utah, there is one sub-region, the Upper Snake.

Within the state of Utah, there are 15 basins nested within the regions and sub-regions. The majority of the basins extend into Utah from other states. These 15 basins contain 68 smaller sub-basins (Figure 4.2; Tables 4.1 and 4.2). The sub-basins are often named for the primary surface waters that are found within that specific sub-basin (Figure 4.1). Each of the 15 basins will be described in terms of physical features, land cover, and general climate. Land cover data were extracted from the generalized SWReGAP data layer (reference section on Vegetation of Utah). Elevation data were extracted from high-resolution digital elevation models, and climate data were extracted from Daymet climate models (Thornton et al., 1997).

GREAT BASIN REGION

ESCALANTE DESERT-SEVIER LAKE BASIN – The Escalante Desert-Sevier Lake Basin is a large basin found within the Escalante Desert-Sevier Lake Sub-region. The basin is almost entirely located within the state boundaries. The basin spans 10 counties, including: Beaver, Garfield, Iron, Juab, Kane, Millard, Piute, Sanpete, Sevier, and Tooele. The basin consists of nine sub-basins, including: the Beaver Bottoms-Upper Beaver, East Fork Sevier, Escalante Desert, Lower Beaver, Lower Sevier, Middle Sevier, San Pitch, Sevier Lake, and Upper Sevier sub-basins. The basin is bounded on the east by the Escalante Mountains, the Awapa Plateau, and the Wasatch Plateau, and it extends west to the House Range, Wah Wah Mountains, Indian Peak Range, and Needle Range. It is bounded on the north by the Tintic Mountains and Mount Nebo, and it extends south to the Paunsaugunt and Markagunt plateaus and the Pine Valley Mountains. The basin encompasses 10,463,981 acres, with 10,392,078 acres in Utah.

Annual precipitation averages 15 inches. Annual reference evapotranspiration is approximately 13 inches, yielding a net surplus in water, largely due to the portion of the Rocky Mountains that occupies the eastern portion of the basin. The dominant vegetation types are pinyon-juniper and big sagebrush. Salt desert shrub types are also prevalent. The topographic diversity and elevational range of this basin (4,400 feet to over 12,000 feet above sea level) also supports a wide array of environments that stretch to subalpine zones. Aspen and spruce-fir communities separated by dry and wet meadows characterize vegetation in the upper elevations.

A key management concern at lower elevations is the spread of cheatgrass that predominantly invades semidesert shrub communities. This is also a significant issue in other basins that span western Utah. Cheatgrass has been blamed for much of the reduction of fire return intervals and the occurrence of larger fires. The Milford Flats fire in July of 2007 burned more than 363,000 acres of land and is considered the largest fire in recorded history of Utah.

GREAT SALT LAKE BASIN – The Great Salt Lake Basin is located in Utah, Nevada, and Idaho and is found within the Great Salt Lake Sub-region. It is the largest basin in the state, spanning nine counties, including: Beaver, Box Elder, Davis, Iron, Juab, Millard, Salt Lake, Tooele, and Weber. The basin contains 10 sub-basins, including: the Curlew Valley, Great Salt Lake, Hamlin-Snake Valleys,

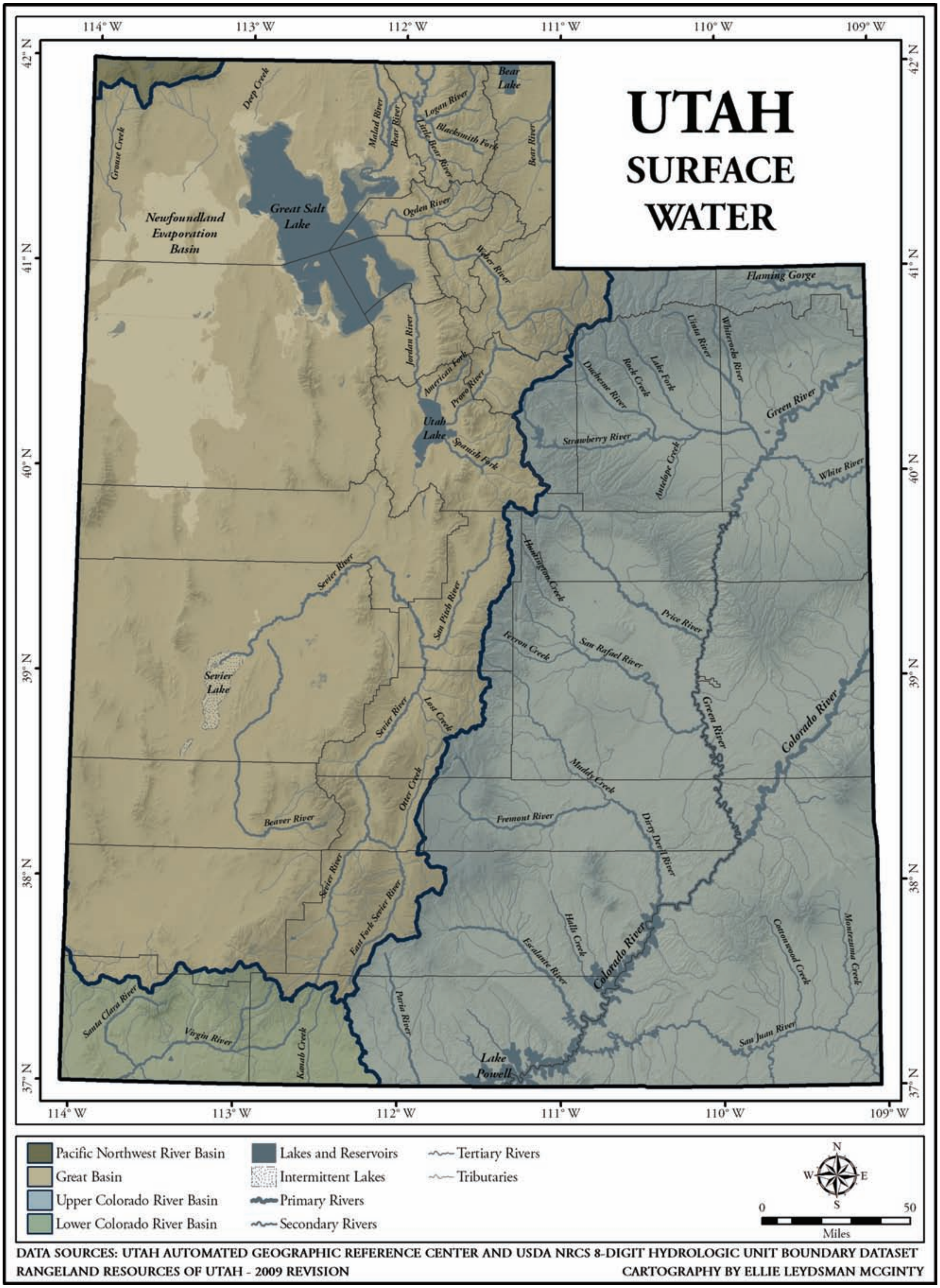


Figure 4.1. Major hydrologic regions and surface water features in Utah.

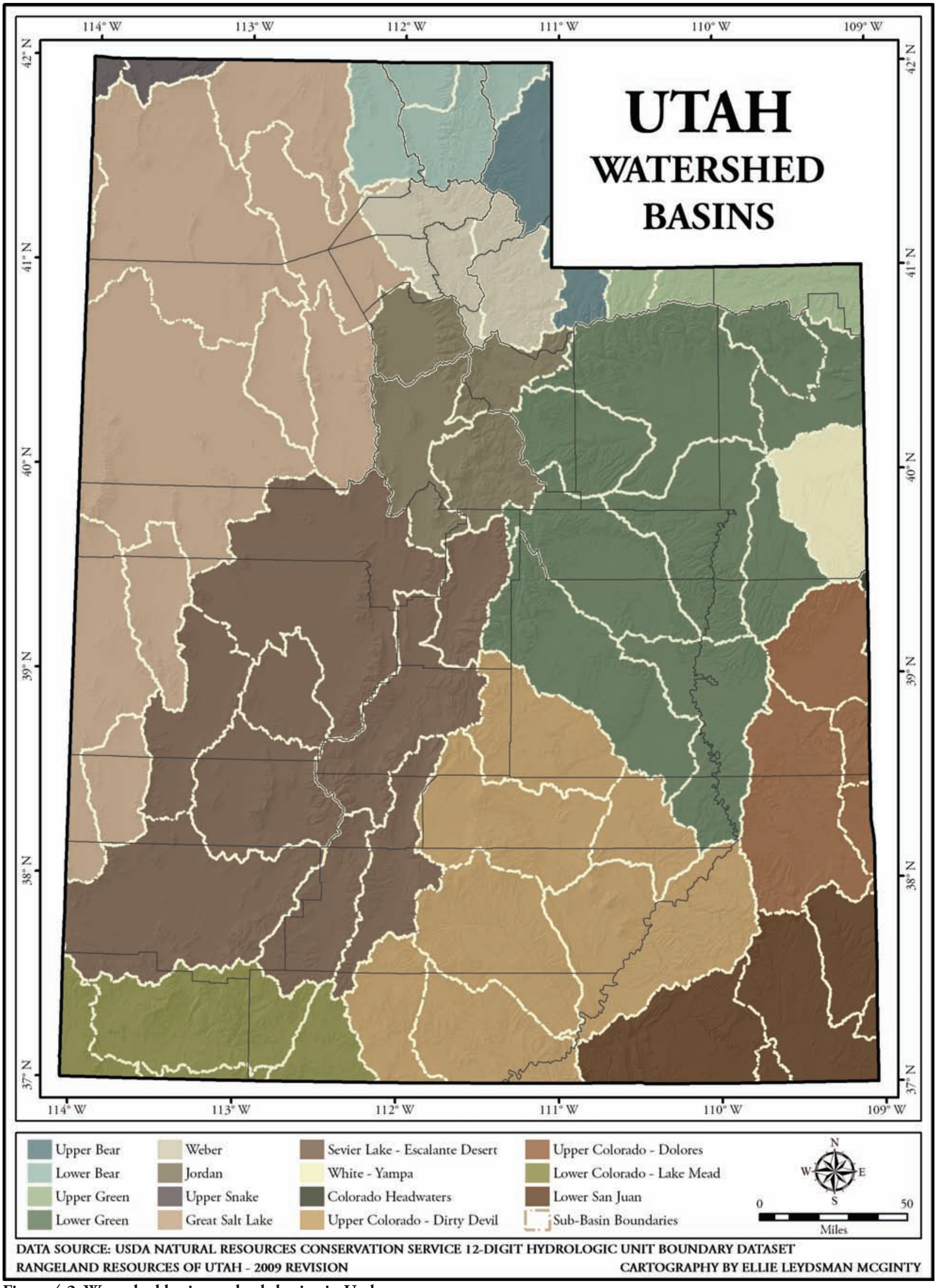


Figure 4.2. Watershed basins and sub-basins in Utah.

Table 4.1. Hydrologic sub-regions, basins, and sub-basins within the Great Basin Region and Pacific Northwest Region.

REGION	SUB-REGION	BASIN	SUB-BASIN
GREAT BASIN REGION	ESCALANTE DESERT - SEVIER LAKE	ESCALANTE DESERT - SEVIER LAKE	Beaver Bottoms-Upper Beaver
			East Fork Sevier
			Escalante Desert
			Lower Beaver
			Lower Sevier
			Middle Sevier
			San Pitch
			Sevier Lake
			Upper Sevier
	GREAT SALT LAKE	GREAT SALT LAKE	Curlew Valley
			Great Salt Lake
			Hamlin-Snake Valleys
			Northern Great Salt Lake Desert
			Pilot-Thousand Springs
			Pine Valley
			Rush-Tooele Valleys
			Skull Valley
			Southern Great Salt Lake Desert
			Tule Valley
		JORDAN	Jordan
			Provo
			Spanish Fork
			Utah Lake
		WEBER	Lower Weber
			Upper Weber
	BEAR RIVER	LOWER BEAR	Bear Lake
			Little Bear-Logan
			Lower Bear-Malad
			Middle Bear
		UPPER BEAR	Central Bear
			Upper Bear
PACIFIC NORTHWEST REGION	UPPER SNAKE	UPPER SNAKE	Goose
			Raft

Table 4.2. Hydrologic sub-regions, basins, and sub-basins within the Lower Colorado Region and Upper Colorado Region.

REGION	SUB-REGION	BASIN	SUB-BASIN
LOWER COLORADO REGION	LOWER COLORADO - LAKE MEAD	LOWER COLORADO - LAKE MEAD	Fort Pierce Wash
			Kanab
			Lower Virgin
			Meadow Valley Wash
			Upper Virgin
UPPER COLORADO REGION	COLORADO HEADWATERS	COLORADO HEADWATERS	Colorado Headwaters-Plateau
	LOWER GREEN	LOWER GREEN	Ashley-Brush
			Duchesne
			Lower Green
			Lower Green-Desolation Canyon
			Lower Green-Diamond
			Price
			San Rafael
			Strawberry
			Willow
	SAN JUAN	LOWER SAN JUAN	Chinle
			Lower San Juan
			Lower San Juan-Four Corners
			McElmo
			Montezuma
	UPPER COLORADO - DIRTY DEVIL	UPPER COLORADO - DIRTY DEVIL	Dirty Devil
			Escalante
			Fremont
			Lower Lake Powell
			Muddy
			Paria
			Upper Lake Powell
	UPPER COLORADO - DOLORES	UPPER COLORADO - DOLORES	Lower Dolores
			Upper Colorado-Kane Springs
			Upper Dolores
			Westwater Canyon
	GREAT DIVIDE - UPPER GREEN	UPPER GREEN	Blacks Fork
			Muddy
			Upper Green-Flaming Gorge Reservoir
	WHITE-YAMPA	WHITE-YAMPA	Lower White

Northern Great Salt Lake Desert, Pilot-Thousand Springs, Pine Valley, Rush-Tooele Valleys, Skull Valley, Southern Great Salt Lake Desert, and Tule Valley sub-basins. The Great Salt Lake Basin extends west from the House Range, Wah Wah Mountains, Oquirrh Mountains, and Promontory Mountains east to the Snake Range, Mount Morah, Kern Mountains, Goshute Mountains, the Pilot Range, and the Goose Creek Mountains. The northern boundary is the Grouse Creek Mountains and Raft River Mountains, and the southern limit is the Needle Range and Indian Peak Mountains. The basin encompasses 14,508,116 acres, with 11,596,392 acres in Utah.

Although it is the largest basin in Utah, the Great Salt Lake Basin is one of the least populated areas, with approximately 1.8 percent of the total population in the state. Eighty-eight percent of this population occupies only 7 percent of the land in the basin. The lack of human population is due to the relatively harsh nature of this basin. It is composed of salty playa bottoms and the Great Salt Lake, and it includes some of the most arid lands in the western United States.

The dominant vegetation cover is salt desert shrub and greasewood. Big sagebrush and pinyon-juniper are found at higher elevations on the "island mountains" that are typical of Basin and Range topography. The mountains provide much of the water, through snowmelt, needed for natural vegetation growth. Annual precipitation averages 12 inches, with most falling as snow on the mountains. The reference evapotranspiration, which is an estimate of the total amount of water evaporated from the surface and transpired by plants, is 13 inches (this assumes that water is not limited). Therefore, on average, all of the water that comes as precipitation is lost to evapotranspiration. Aside from the mountain ranges, there are areas that produce significant amounts of vegetation. These can be found along the shorelines of the Great Salt Lake and around perennial springs, such as Fish Springs National Wildlife Refuge, and other small bodies of water and springs.

JORDAN RIVER BASIN – The Jordan River Basin is located within the Great Salt Lake Sub-region, and it resides entirely within the state of Utah. The basin spans across six counties, including: Juab, Salt Lake, Sanpete, Summit, Utah, and Wasatch. The basin contains four sub-basins, including: the Jordan, Provo, Spanish Fork, and Utah Lake sub-basins. The basin is bounded on the west by the Oquirrh Mountains and the Great Salt Lake and on the east by the Uinta Mountains and the Wasatch Plateau. It is bounded on the south by the San Pitch and Tintic Mountains and on the north by the Great Salt Lake and the Wasatch Range. The basin encompasses 2,502,664 acres, all within Utah.

This basin covers the most urbanized portion of Utah with at least 10 percent of the total land area classified as urban development. The natural land cover consists predominantly of upland zone types, such as Gambel oak, big sagebrush, and pinyon-juniper. Since this basin ranges from a low elevation of approximately 4,200 feet to a high of 11,900 feet, the vegetation cover also includes conifers, aspen, mountain meadows, and tall shrublands. Precipitation averages 25 inches per year; therefore, the subsequent water production is slightly less per unit area than the Weber River Basin, with approximately the same allocation between natural land cover, agriculture, and human use. One significant difference between the Jordan River Basin and the other basins in Utah is the influx of water through the Central Utah Water Project, which pipes water from the High Uintas to the central part of the state.

WEBER RIVER BASIN – The Weber River Basin is located within the Great Salt Lake Sub-region. The basin occurs in Box Elder, Davis, Morgan, Summit, and Weber counties in Utah and in Uinta County, Wyoming. The basin contains two sub-basins, including the Lower Weber and the Upper Weber. The basin is bordered on the east by the Uinta Mountains and the Monte Cristo Range and extends to the Great Salt Lake on the west. Mountains of the Bear River and Wasatch Ranges form the northern boundary, while the Summit-Wasatch County divide forms the southern boundary. The total area of the Weber River Basin is 1,571,254 acres, with 1,565,707 acres in Utah.

The land cover and land use of this basin includes vegetation common to the upland through subalpine zones. Mountain big sagebrush is a dominant land cover followed by Gambel oak, aspen, and spruce-fir. Land use consists of developed land and agriculture. The basin has the highest amount of average precipitation per year with 27 inches. Much of this precipitation comes as snow. The Utah Division of Water Resources estimates that this basin produces approximately 3.5 million acre-feet of water, of which 68 percent is used by the natural vegetation. Slightly over 7 percent of the available water is utilized by agriculture and development. The remainder flows into the Great Salt Lake (UDWaR, 2004a).

LOWER BEAR RIVER BASIN – The Lower Bear River Basin is located within the Bear River Sub-region, and it spans Box Elder, Cache, and Rich counties in Utah and in Bear Lake, Franklin, and Oneida counties in Idaho. The basin contains four sub-basins, including: the Bear Lake, Little Bear-Logan, Lower Bear-Malad, and Middle Bear sub-basins. The Pleasantview Hills, the Samaria Mountains, and Promontory Mountains bound the basin on the west, while the Boundary and Bear Lake Ridges and the Monte Cristo Range bound it on the east. The northern limits of the basin are in Idaho and are bound by the Bannock, Portneuf, Chesterfield, and Preuss Ranges. The basin is bounded on the south by the Cache-Weber County divide. The basin encompasses 2,924,293 acres, with 1,342,011 acres in Utah.

The Lower Bear River Basin, along with the adjacent Upper Bear River Basin, comprise approximately one-half of the Bear River Sub-region. The main drainage is the Bear River. The Bear River travels north from Summit County through southwestern Wyoming and Rich County. The river crosses into Idaho just north of Bear Lake where it travels to Soda Springs, Idaho. It then turns south, travelling through Franklin County, Idaho, and then through Cache and Box Elder counties in Utah, and eventually draining into the Great Salt Lake.

The Utah portion of this basin is primarily composed of big sagebrush-steppe environments along with a few instances of salt desert scrub and greasewood in Rich County. Upper elevations support plant communities common to the upland, mountain, high-mountain, and subalpine zones. A significant land use in this basin is agriculture, which predominates in the Middle Bear and Lower Bear-Malad sub-basins.

According to the Utah Division of Water Resources, the Lower Bear River and Upper Bear River basins receive an average of 22 inches of precipitation that produces approximately 4 million acre-feet of water within Utah. The native vegetation utilizes 60 percent of this water, while 7 percent is used for agriculture. Municipal water use accounts for 0.5 percent of the total. The remaining water flows into the Great Salt Lake (UDWaR, 2004b). These two basins are two of the few in Utah that have a significant amount of excess water.

UPPER BEAR RIVER BASIN – The Upper Bear River Basin is located within the Bear River Sub-region and it contains the headwaters of the Bear River. The basin contains one sub-basin, the Upper Bear Sub-basin, which is located in Rich and Summit counties in Utah and in Uinta and Lincoln counties in Wyoming. The basin is bounded on the east by the Bear River Divide and extends west to the Monte Cristo Range and Bear Lake Ridge. The northern boundary is the Bear Lake Plateau, the Salt River Range, and Commissary Ridge. The basin is bounded on the south by the Uinta Mountains. The total area included in the basin is 1,270,344 acres, with 678,733 acres in Utah.

The vegetation is similar to that of the Lower Bear River Basin, with sagebrush and agriculture dominating. The difference between the two is that the Upper Bear River Basin contains higher elevation areas and has a higher amount of high-mountain and subalpine vegetation.

UPPER COLORADO REGION

COLORADO HEADWATERS BASIN – The Colorado Headwaters Basin is located within the Colorado Headwaters Sub-region. The basin consists of only a small portion of one sub-basin on the Utah-Colorado border called the Colorado Headwaters-Plateau Sub-basin. It is bounded on the north and east by the Book Cliffs, on the southeast by the Uncompahgre Plateau, and on the west by the divide of the White-Yampa Basin and the Upper Colorado-Dolores Basin. The basin encompasses a total of 1,997,656 acres, with only 10,805 acres located in Utah.

UPPER COLORADO-DOLORES RIVER BASIN – The Upper Colorado-Dolores River Basin is located within the Upper Colorado-Dolores River Sub-region, and it spans two counties in Utah, including San Juan and Grand, and it extends into Colorado on the east. It is composed of four sub-basins, the Upper and Lower Dolores sub-basins, which are primarily located in Colorado, and the Upper Colorado-Kane Springs and Westwater Canyon sub-basins, which are primarily located in Utah.

The basin is bounded on the east by Grand Mesa and Uncompahgre Plateau and on the west by Grand View Point, other higher elevation landforms, and the Abajo Mountains. It is bounded on the north by the Book Cliffs and on the south by the Abajo Mountains, high ridges, and plateaus. The Upper Colorado-Dolores River Basin encompasses 4,311,848 acres, with 2,509,832 acres in Utah.

Elevations in the Utah portion of this basin range from a low of 2,861 feet to a high of 12,727 feet in the La Sal Mountains. This basin encompasses a variety of ecosystems from desert to alpine zones. The majority of the basin is classified as semidesert. Composition of vegetation communities by area of the basin, however, make pinyon-juniper communities the dominant vegetation type, with tableland (slickrock) environments, big sagebrush, and blackbrush-Mormon tea communities in roughly equal proportions. Smaller components include salt desert shrub types that consist of shadscale, mat saltbush, and greasewood. Annual precipitation averages 14 inches, with an equal amount of potential evapotranspiration.

UPPER COLORADO-DIRTY DEVIL BASIN – The Upper Colorado-Dirty Devil River Basin is a large basin located within the Upper Colorado-Dirty Devil River Sub-basin. The basin spans eight counties in Utah, including: Emery, Garfield, Kane, Piute, San Juan, Sanpete, Sevier, and Wayne, and extends south into Arizona. The basin contains seven sub-basins, including: the Dirty Devil, Escalante, Fremont, Lower Lake Powell, Muddy, and Paria sub-basins. The basin is bounded on the east by the Abajo Mountains and on the west by the Vermillion Cliffs, White Cliffs, the Aquarius Plateau and the Wasatch Plateau on the west and north. The basin extends to the Paria Plateau on the south. It is comprised of 8,788,890 acres, including 7,565,573 acres in Utah.

Elevations vary from 3,681 feet at Lake Powell to 11,624 feet at Mt. Marvine in Sevier County. Land cover is dominated by pinyon-juniper, with an equal amount of tablelands (slickrock) at the lower elevations. Other common vegetation communities include blackbrush-Mormon tea and big sagebrush shrublands and steppes. Precipitation averages 11 inches per year, with an average of 14 inches of potential evapotranspiration, yielding a water deficit.

Land uses in this basin range from traditional livestock grazing to recreational activities, such as backpacking, camping, and boating (in Lake Powell). This area of Utah hosts a number of recreational opportunities, including Bryce Canyon National Park, Capitol Reef National Park, the Grand Staircase-Escalante National Monument, the Glen Canyon Recreation Area, and the southern extent of Canyonlands National Park.

UPPER GREEN RIVER BASIN – The Upper Green River Basin is located within the Great Divide-Upper Green Sub-basin and it is primarily found in Wyoming. The small portion that extends south into Utah is located in Daggett, Summit, and Uintah counties. Three sub-basins occur in Utah, including: the Blacks Fork, Muddy, and Upper Green-Flaming Gorge Reservoir sub-basins. The Upper Green River Basin is bounded by the Wind River Mountains on the north extending south to the Uinta Mountains. It is bounded on the west by the Bear River Divide and the Salt Mountains and on the east by the Owiyukuts Mountains, the Aspen Mountains, and the Upper Green-Slate Sub-basin. The Upper Green River Basin encompasses 3,921,611 total acres of which 847,672 acres are located in Utah.

The Upper Green River Basin occupies the north slope of the High Uinta Mountains and has an elevation range of 5,369 feet at Flaming Gorge Reservoir to 13,528 feet at Kings Peak. The broad elevation range yields a variety of vegetation communities, ranging from the semidesert to the alpine. Lodgepole pine dominates this basin, followed closely by big sagebrush, pinyon-juniper, and spruce-fir. Smaller occurrences of ponderosa pine, aspen, agriculture, and meadow can also be found in the basin. Annual precipitation is high relative to most other basins in Utah and averages 21 inches per year with an estimated 9 inches of evapotranspiration, thus providing a potentially large surplus of water.

LOWER GREEN RIVER BASIN – The Lower Green River Basin is located within the Lower Green Sub-basin, and it spans 10 counties in Utah, including: Carbon, Duchesne, Emery, Garfield, Grand, San Juan, Sanpete, Uintah, Utah, and Wayne. The basin contains nine sub-basins, including: the Ashley-Brush, Duchesne, Lower Green, Lower Green-Desolation Canyon, Lower Green-Diamond, Price, San Rafael, Strawberry, and Willow sub-basins. The basin extends from the Wasatch Mountains and Wasatch Plateau on the west to the East Tavaputs Plateau on the east. The basin is bounded by the Uinta Mountains on the north and high desert ridges to the south. The Lower Green River Basin encompasses 9,299,227 acres, with 9,251,234 acres in Utah.

The Lower Green River Basin has the broadest elevation range of any of the basins in the state. The lowest elevation is 3,866 feet at the confluence of the Green and Colorado rivers, while the highest elevation is Kings Peak in the High Uintas at 13,528 feet. This basin stretches from the desert to the alpine zones, and the different types of vegetation communities and land uses reflect this diversity. Identifying a short list of communities that dominate this basin is difficult due to the diversity of life zones.

Precipitation across this basin is equally diverse, but it averages 15 inches annually. The average annual reference evapotranspiration is 12 inches, giving the basin as a whole a net surplus of water. This water balance, however, varies drastically across the basin. Precipitation ranges from 45 inches to just under 7 inches annually across the basin. Reference evapotranspiration ranges from 5 inches to under 16 inches, with an inverse relationship with precipitation. This means that the upper elevation areas that receive the most precipitation have the least amount of loss due to evapotranspiration.

WHITE-YAMPA RIVER BASIN – The White-Yampa River Basin is located within the White-Yampa Sub-basin, and is found in Uintah County, Utah, and Moffat and Rio Blanco counties in Colorado. The basin contains one sub-basin that extends into Utah, the Lower White Sub-basin. The Lower White Sub-basin is bounded on the northeast by Blue Mountain (Yampa Plateau), on the southeast by the mountains of the Roan Plateau, and on the west at the confluence of the White and Green rivers. The basin encompasses 1,703,519 acres, with 771,194 acres in Utah.

Elevations in this basin range from 4,662 feet to 8,572 feet. The majority of the land area is classified as semidesert. Vegetation is dominated by big sagebrush and pinyon-juniper. The remainder of the land area is split between salt desert shrubs, tableland, badlands, and cheatgrass. Precipitation averages 12 inches on an annual basis, with 13 inches of potential evapotranspiration.

LOWER SAN JUAN RIVER BASIN – The Lower San Juan River Basin is located within the San Juan Sub-region and is found in San Juan County, Utah. The basin includes portions of five sub-basins that drain into the San Juan River and parts of each of the Four-Corner States (Utah, New Mexico, Colorado, and Arizona). The sub-basins include the Chinle, Lower San Juan, Lower San Juan-Four Corners, McElmo, and Montezuma. The Lower San Juan River Basin extends from near Dolores and Cortez, Colorado, on the east to the confluence of the old channels of the Colorado and the San Juan rivers on the west. It extends from north of Monticello, Utah, to south of Chinle, Arizona. The basin encompasses a large portion of San Juan County, and comprises a total land area of 6,621,140 acres, with 2,721,868 acres in Utah.

This basin is predominantly characterized by the semidesert zones however, the desert zone consist of more than one-third of the basin. The precipitation averages 10 inches per year with a 15-inch reference evapotranspiration potential, yielding a particularly arid basin. Vegetation is characteristic of semiarid and arid ecosystems, with a majority of pinyon-juniper, blackbrush-Mormon tea, and tableland. Big sagebrush, shrub-steppe, and salt desert shrubs are minority components. Elevations range from 3,676 feet to 11,368 feet.

LOWER COLORADO REGION

LOWER COLORADO-LAKE MEAD BASIN – The Lower Colorado-Lake Mead Basin is located within the Lower Colorado-Lake Mead Sub-region, and in Utah, it is found in Washington and Kane counties. Portions of five sub-basins occur in Utah, including: the Fort Pierce Wash, Kanab, Lower Virgin, Meadow Valley Wash, and Upper Virgin sub-basins. The Virgin River, with its tributaries, the Santa Clara River, the Fort Pierce Wash, and Kanab Creek, ultimately flow into the Colorado River and Lake Mead. The basin extends from the Kaibab Plateau on the east to a basin boundary in Nevada to the west. It extends from the Pine Valley Mountains on the north to the Virgin Mountains, Mount Trumbull, Mount Logan, Poverty Mountain, the Grand Wash Cliffs, and various plateaus (Kaibab, Shivwits) on the south. The basin encompasses a total area of 7,005,328 acres, with 2,226,929 acres in Utah.

The majority of the basin falls within the semidesert zone. The elevation ranges between 2,178 feet, corresponding to the lowest part of the state (Beaver Dam Wash), and 10,379 feet at the peak of Blowhard Mountain on the Dixie National Forest immediately south of Cedar Breaks National Monument. Vegetation in this basin consists mostly of pinyon-juniper with big sagebrush communities. Vegetation also consists of creosote-white bursage and other Mojave vegetation, including Joshua tree and blackbrush. Higher elevations within the basin include oak, aspen, ponderosa pine, and spruce fir. Annual precipitation averages 16 inches and the reference evapotranspiration is 14 inches. This positive water balance is due to the semidesert and upland portions that provide the majority of the runoff.

PACIFIC NORTHWEST REGION

UPPER SNAKE RIVER BASIN – The Upper Snake River Basin is located within the Upper Snake Sub-region, and is found in Box Elder County, Utah; Elko County, Nevada; and Cassia County, Idaho. In Utah, the basin contains two sub-basins, including the Goose and Raft. The Raft River Mountains and Goose Creek Mountains bound the basin on the south, while the Snake River bounds it on the north. The basin is bounded on the west by Rams Horn Ridge, Trapper Peak, and Monument Peak and on the east by the Sublett Range. The Upper Snake River Basin encompasses 1,692,795 acres, with 248,929 acres in Utah.

The snowpack of the Raft and Goose Creek Mountains provides this basin with moisture. Annual precipitation averages 19 inches, with the majority of it falling as winter snow. Elevations span the semidesert and mountain zones. The majority of the land is occupied by big sagebrush shrublands, sagebrush steppe, and mountain big sagebrush, followed by pinyon-juniper communities. Upper elevations include spruce-fir predominantly on the cooler, north facing slopes and aspen communities. Grassy dry meadows and mountain shrub communities are also common at the higher elevations.

Climate of Utah

Robert R. Gillies
R. Douglas Ramsey

Climate in Utah is greatly influenced by its location within the North American Continent with significant local modifications due to topography. Northern, higher-latitude locations are generally cooler than southern, lower-latitude locations. Likewise, higher-elevation locations are typically cooler and wetter than lower-elevation locations.

The regional wind pattern for a mid-latitude location, such as Utah, is generally from west to east. As a general rule, Pacific storms traveling across the Western United States are very moist. As that air meets the backslope of the western mountain ranges, the air is forced upward due to orographic lifting. The subsequent adiabatic cooling reduces the moisture content of the air mass. As a result, the Sierra Nevada and the Cascade Ranges of California, as well as the Rocky Mountains of Utah, receive a significant amount of precipitation. While comparatively dry, light precipitation conditions are the outcome for most of the other regions of Utah. Moreover, this phenomenon explains, to a large degree, the distribution of settlements and agricultural production in Utah and is a significant driver in the distribution of ecosystems that will be discussed later.

Utah is home to a large variety of terrain. Mountain ranges and high plateaus generally extend in a north-south orientation across much of the state and are most prominently found along the central east-west portion of Utah. These include the Wasatch, Bear River, and Pahvant ranges, and the Oquirrh, Stansbury, Tushar Mountains, and Wasatch, Fish Lake, Markagunt, Paunsaugunt and Aquarius plateaus. The Uinta Mountains span east to west in the northeast corner of Utah and contain the highest elevations in the state. Mid-to-high elevation valleys and basins are found near these mountain ranges. Desert plateaus and slick rock canyons are prevalent in the south and southeast regions, while desert valleys cover much of the western third of the state.

The National Climate Data Center (NCDC) has defined the following seven climate divisions for Utah: Western, Dixie, North Central, South Central, Northern Mountains, Uinta Basin, and Southeast (Figure 5.1). These divisions are organized such that the terrain within each region is similar, and the associated weather stations experience the same general climate conditions. There have been many efforts to partition the state into similar units such as these climate divisions. While these various classifications have different purposes, they invariably have relatively similar results since environments in Utah are regionally driven by climate.

According to the Köppen-Geiger climate classification, much of Utah is classified as a steppe, or semiarid region. Of the seven climate divisions listed above, this climate characterization encompasses the Western, Dixie, Southeast, Uinta Basin, and much of the North and South Central divisions. Steppe regions typically experience hot, dry summers and cold winters with average annual precipitation totals of 5 to 15 inches.

The mountainous areas and higher elevation valleys of Utah include the Northern Mountains and portions of the Uinta Basin, Southeast, and North and South Central divisions. These areas are characterized as Humid Continental with no real dry season and warm-to-hot summers. Winters are severe with cold temperatures and abundant snowfall. Annual precipitation amounts can range from 10 to more than 55 inches (Figure 5.2). High elevation mountain stations like Alta, Utah, for example, normally receive over 500 inches of snowfall that contribute to its average of 58 inches of precipitation (water equivalent) annually. The Uinta Mountains and other mountainous areas with elevations over 11,000 feet are classified as subarctic. Here there is no dry season. Cool summers and severe, cold winters characterize these mountain areas.

Given the different climate zones in Utah, there is some similarity among them as to when the majority of precipitation in a year is received. Generally, the winter months bring the highest amounts of monthly precipitation. This is due to the Polar Jet Stream that moves southward in winter and often places Utah in the path of strong Pacific storm systems moving in from the northwest. The summer months generally bring the driest weather to Utah as the Polar Jet Stream lies further to the north and high pressure prevails over much of the region. Precipitation in the summer months is generally limited to convective thunderstorm activity. Thunderstorms occur more often over the mountains as warm air rises from the surface of multiple sides of a mountain ridge converging at the top of the ridge. Summer precipitation in the eastern portion of Utah increases around the latter part of the summer season as high pressure moves eastward, creating a so-

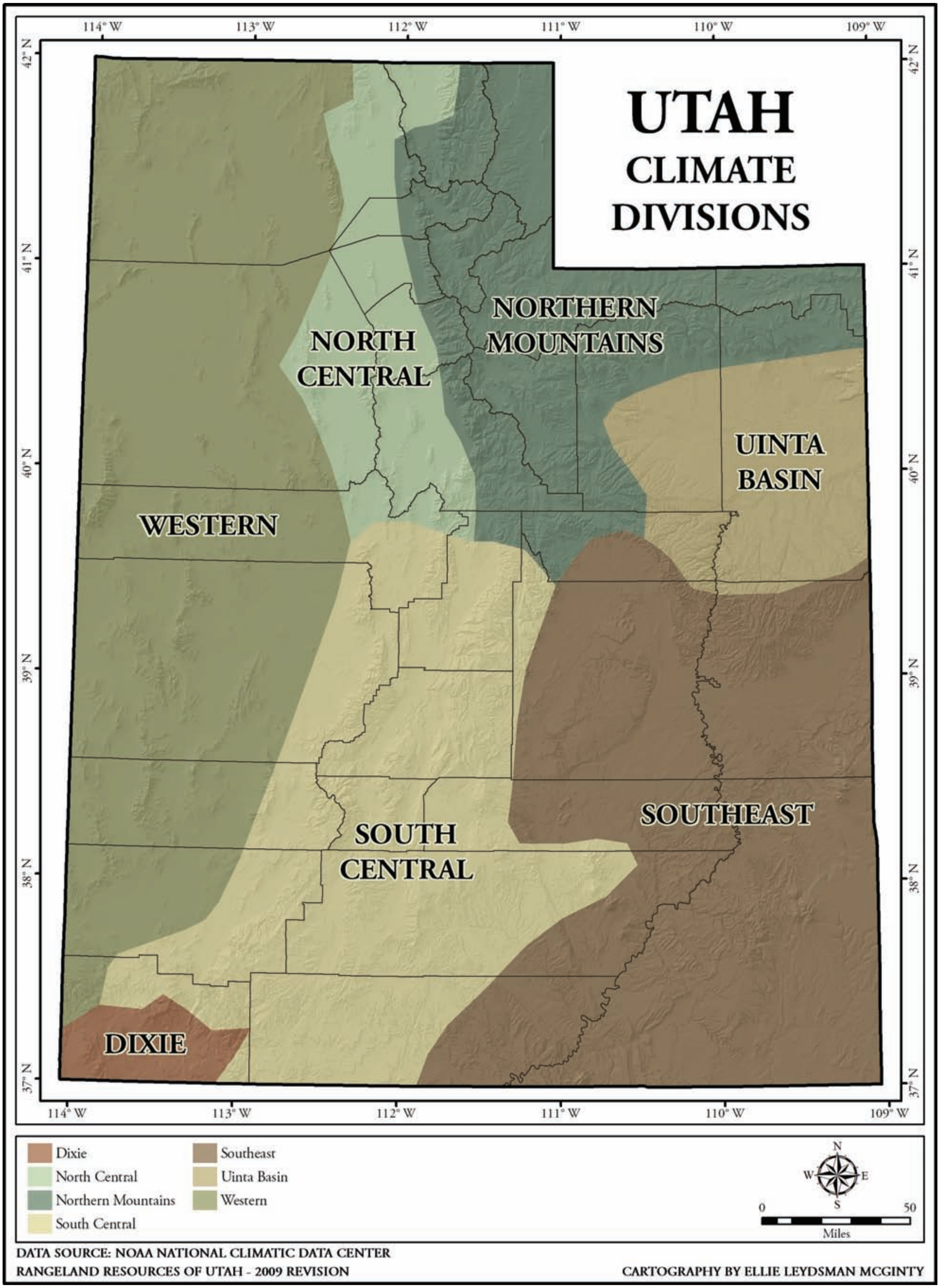


Figure 5.1. NOAA National Climatic Data Center climate division.

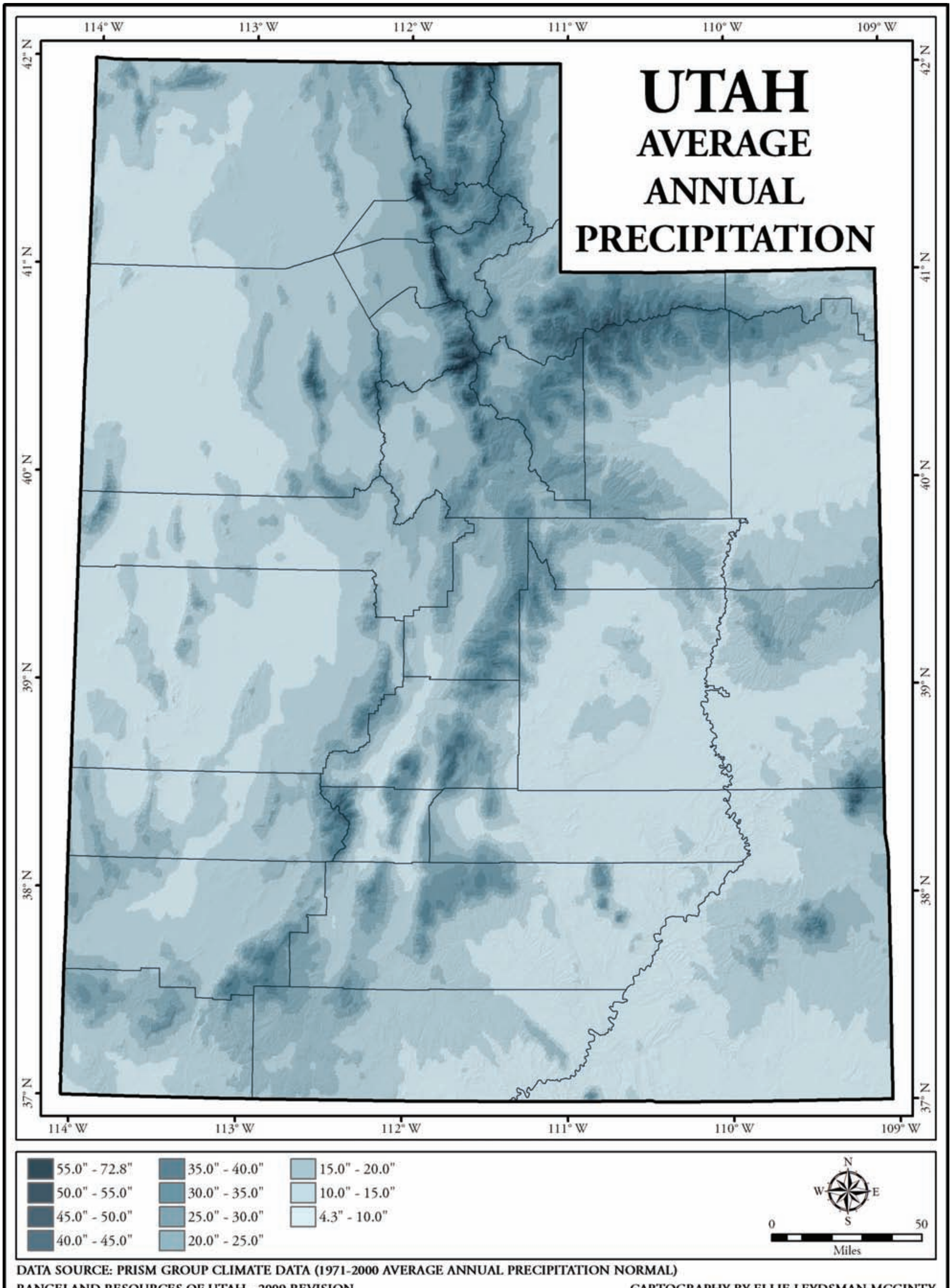


Figure 5.2. Average annual precipitation in Utah.

called monsoonal flow from the south. The monsoonal flow draws moist air from the Gulf of California, the Gulf of Mexico, and the Pacific Ocean into the Intermountain Region, generally affecting mostly the southern and southeastern part of the state with some rainfall activity in the north, depending on the location of the Polar Jet Stream. The moist air combined with afternoon heating brings an increased chance for thunderstorm activity.

The semiarid characteristic of the state is primarily due to the balance between total precipitation (PPT) and the total reference evapotranspiration (RET). The RET is the total amount of water that is evaporated from the ground surface and transpired from plants for a given time period and assumes that available moisture is not limited (Figure 5.3). Therefore, areas where total RET is greater than total PPT are considered dry because more water is extracted than provided, and areas where RET is less than PPT are considered wet. Using this reference, approximately 91 percent of the state experiences dry climatic conditions throughout the year (Figure 5.4). These conditions vary on a monthly basis.

The controlling variable for the calculation of RET is temperature. As with precipitation, temperature varies across Utah primarily as a function of elevation and latitude (Figure 5.5). Northern Utah is typically cooler than southern Utah and higher elevations are generally cooler than lower areas. Therefore, precipitation and temperature working together are the primary drivers of the distribution of vegetation in the state. At local scales, soils and topographic relief also strongly affect plant distributions.

Other climate features of note are inversion conditions that occur during late fall and winter months. These may persist for several weeks. In natural settings, this results in long-lasting fog, while in the inhabited valleys of northwestern Utah, car exhausts and smoke accumulate to form haze in the stagnant air.

Climatologically, winds are generally moderate but from time to time, they reach damaging proportions in the vicinity of canyons along the western edges of the Wasatch Mountains, especially if there is a temperature inversion aloft. Dust storms occur occasionally in spring and mostly in western Utah.

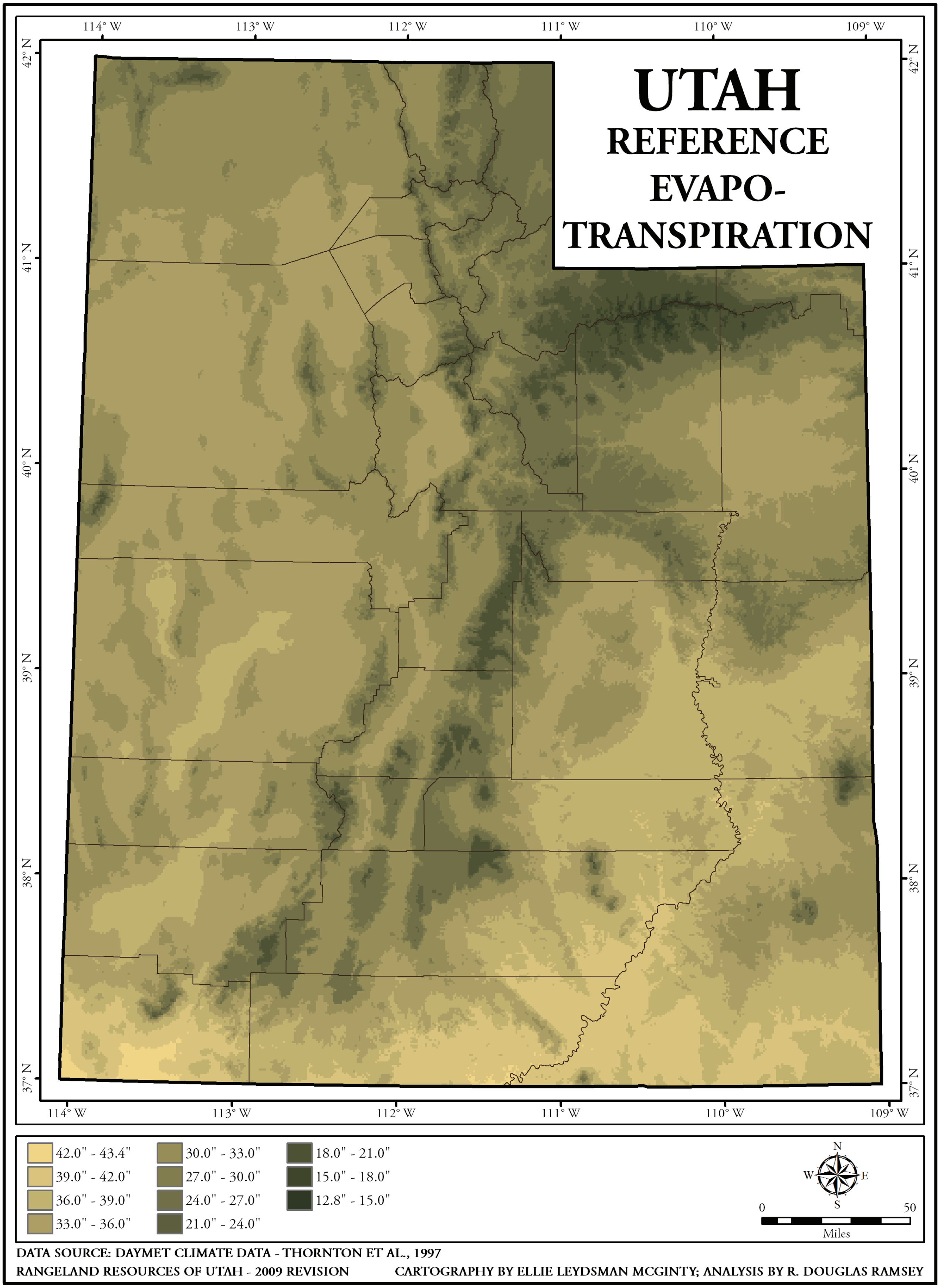


Figure 5.3. Average annual reference evapotranspiration in Utah.

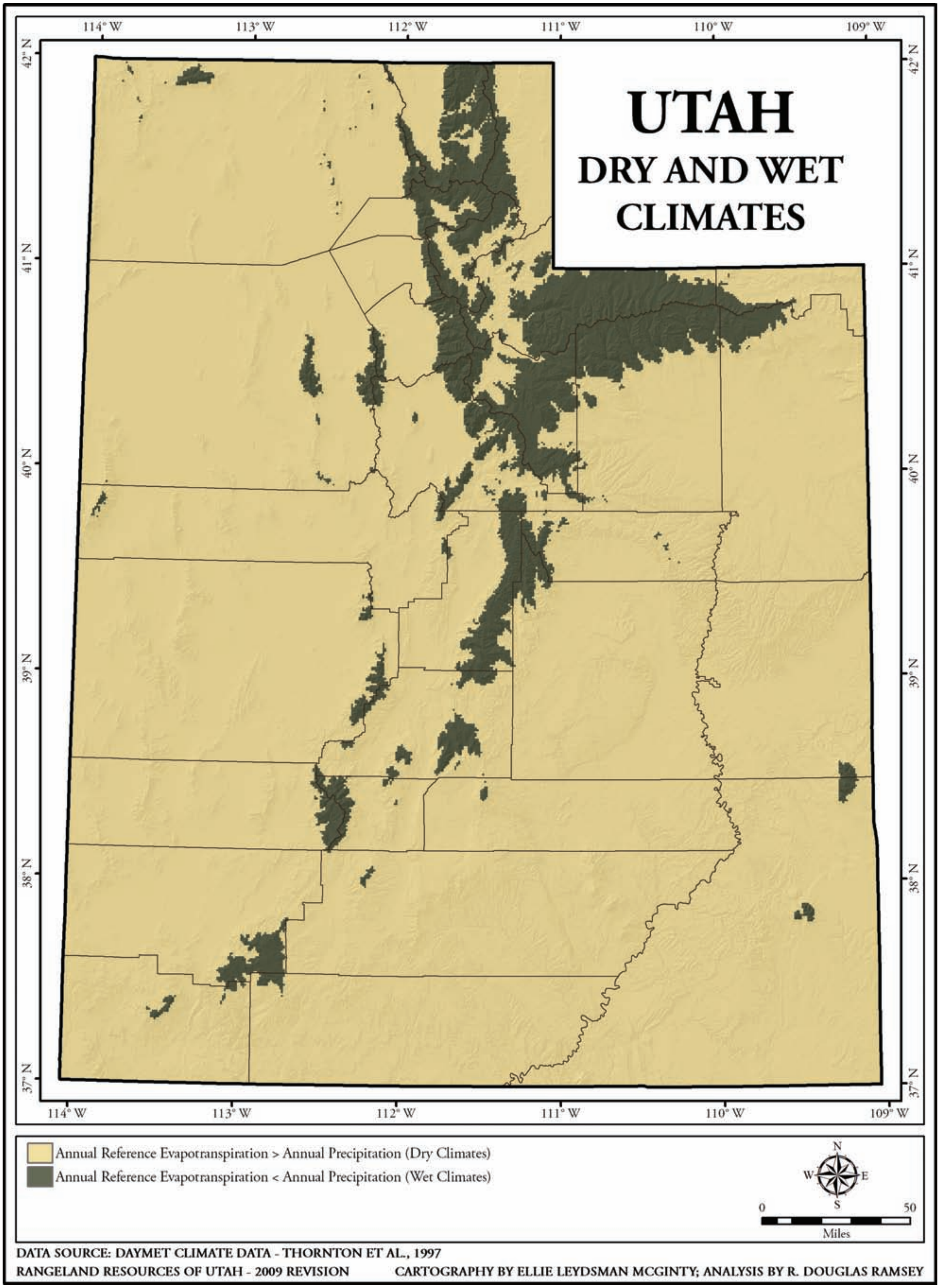


Figure 5.4. Dry and wet climates in Utah.

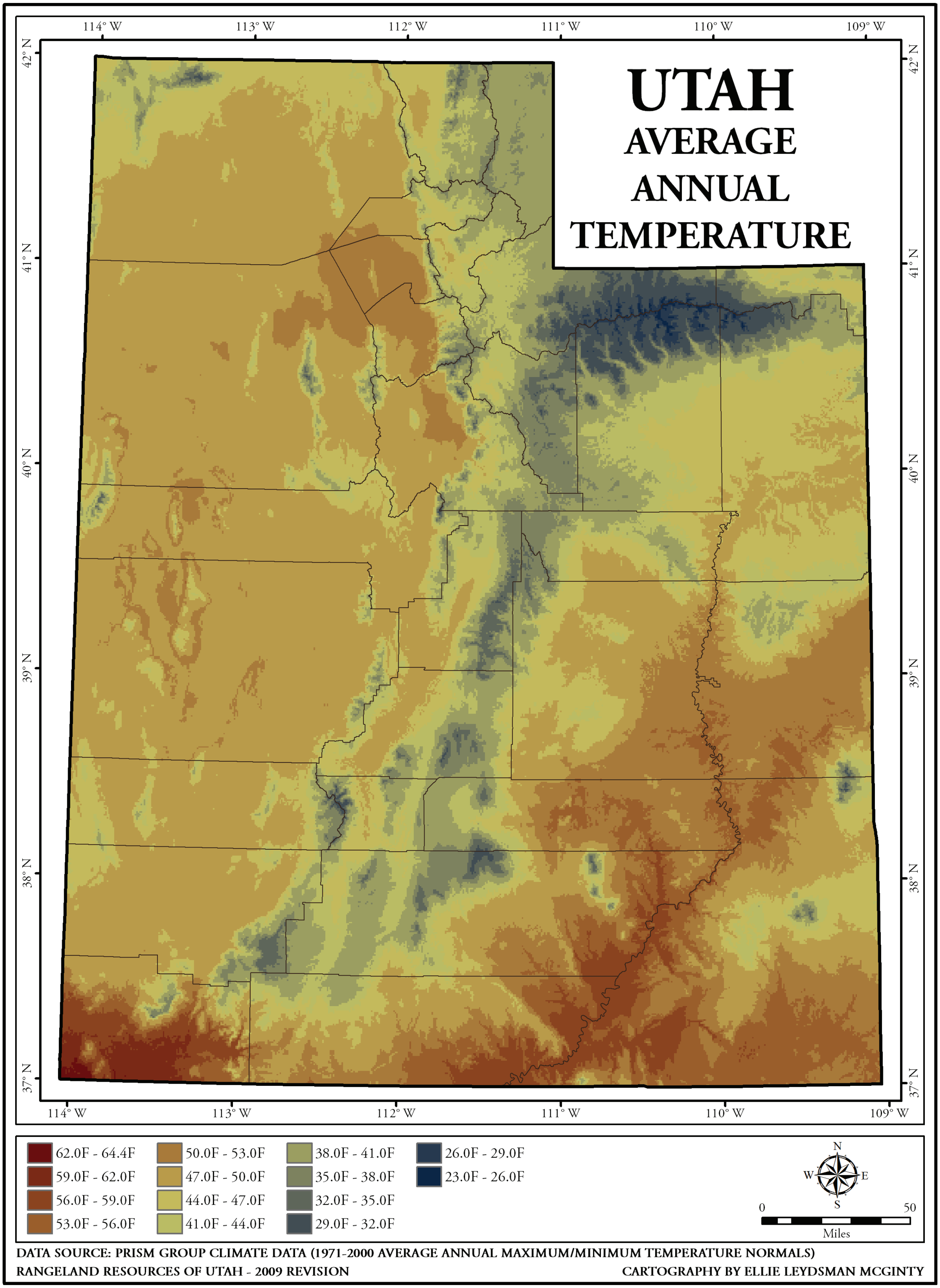


Figure 5.5. Average annual temperature in Utah.

Soils of Utah

Janis L. Boettinger

The varied geology, topography, and climatic conditions in Utah have produced soils with unique characteristics and distributions. In general, soils of the mountains and benches are slightly acidic to neutral with thick, dark-colored surface horizons, while soils of the deserts are alkaline and lightly colored. Extensive areas of outcropping rock, drifting sand dunes, and playa lakebeds also characterize the state of Utah. The distributions of soils in Utah were mapped and updated by the Natural Resources Conservation Service and the National Cooperative Soil Survey in 2006. The United States General Soil Map (STATSGO2) was created by generalizing more detailed soil survey maps. Where more detailed soil survey maps were not available, data on geology, topography, vegetation, and climate were assembled, and integrated with Land Remote Sensing Satellite (LANDSAT) images, to determine soil orders and extents (NRCS, 2009b). Seven of the twelve soil orders are found in the state of Utah. Aridisols, Entisols, and Mollisols dominate, followed by Alfisols and Inceptisols (Figure 6.1). Histosols and Vertisols occur in very small tracts where parent material or moisture influences their formation.

SOIL ORDERS

Alfisols – Alfisols are moderately leached soils that have a thin and light colored surface horizon. They are characterized by an accumulation of clay in the subsoil. Although Alfisols are primarily found in temperate humid and subhumid regions of the world, some suborders of Alfisols in Utah occur on low-lake terraces and alluvial fans that have formed under the influence of a seasonal water table and sodium. Accordingly, the soil horizons are strongly alkaline and vegetation growing within them includes salt-tolerant grasses and shrubs. Other suborders of Alfisols occur in high mountains under timber, particularly conifers. These Alfisols are characterized by a thin organic layer and a thin dark surface horizon, underlain by a pale horizon from which clay has moved to the subsoil.

Aridisols – Aridisols occur where annual precipitation is less than 12 inches and the soil has experienced some development, such as subsoil accumulations of carbonates, clays, silica, salts, or gypsum. Long and dry summers contribute to the formation of this soil order. Aridisols have a light color because the arid climate typically limits plant biomass production and the accumulation of organic matter. They are moderately to very strongly alkaline, and they often have significant accumulations of calcium carbonate in the subsoil. In many locations they contain a carbonate-cemented hardpan at some depth in the soil profile.

In Utah, Aridisols are found extensively within the Great Basin, the Bear River Valley of Rich County, the Uinta Basin, the Green River Basin, the Sevier River Drainage Basin, and the Colorado Plateau. Within these regions, Aridisols occur on lower terraces, on fan slopes, and in desert valleys. Aridisols support drought resistant vegetation. Sagebrush species, saltbush species, and greasewood are the dominant vegetation types, but their presence and distribution are highly dependent on the soil depth, texture, salinity, and alkalinity. Aridisols also support Joshua tree and yucca in the lower elevations of the Mojave Desert in the southwestern corner of the state. Juniper and pinyon pine are found in the intergrade zone of Aridisols and Mollisols. Aridisols are commonly associated with Entisols and areas adjacent to and within playa, sand dune, and rock outcrop formations. Some irrigated farming occurs on Aridisols, but without irrigation they can be managed for livestock grazing, wildlife habitat, and recreation.

Entisols – Entisols are soils of recent origin that do not have discernible horizons with the exception of some darkening of the surface. They occur on younger alluvial terraces and fans, along some valley bottoms, and on stream floodplains. Entisols also occur as shallow soils on bedrock uplands in arid regions. The color of Entisols varies from light to dark, depending on the parent material. Entisols are common in the Great Basin, Colorado Plateau, and Uinta Basin, and can occupy small areas on recent floodplains in any region. Entisols are most often associated with Aridisols, Mollisols, Inceptisols, and Alfisols.

Inceptisols – Inceptisols are weakly developed soils found on relatively young geomorphic surfaces. They are more developed than Entisols, but they still lack the features that are characteristic of other soil orders. A sizeable percentage of Inceptisols are found in mountainous areas. Subsoil horizons are characterized by translocated carbonates, a brightening of the color in the subsoil, and development of subsoil structure. Inceptisols form in semiarid, sub-humid, and cool humid climates. On steep slopes in sub-humid areas, Inceptisols occupy south and west aspects. Vegetation and land use varies considerably with Inceptisols, as small areas of Inceptisols have been mapped in diverse places in Utah.

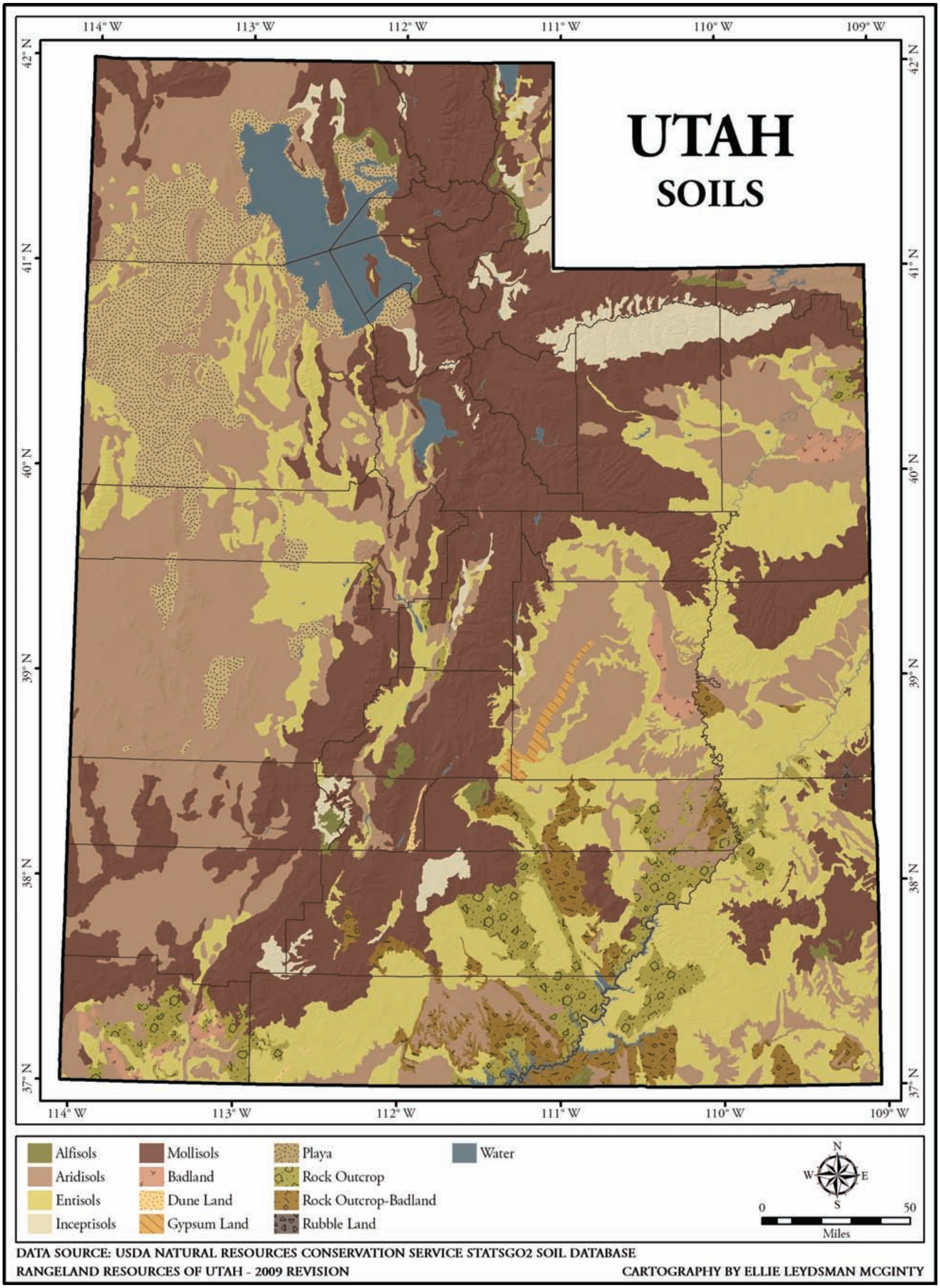


Figure 6.1. Primary soil orders and landforms in Utah.

Mollisols – Mollisols are characterized by a thick, dark, relatively fertile surface soil. They typically form under grassland vegetation, in semiarid to sub-humid shrub steppe, or in forested zones under aspen and where grasses and forbs are important components of the understory. Mollisols are rich in humus (dead and decayed plant matter contributed mainly by the fine root turnover by grasses, forbs, and shrubs). Humus stores mineral nutrients, contributes to the capacity of the soil for retaining nutrients and water, and gives the soil its dark color. The structure of the surface soil is granular with soft to slightly hard consistency. The base saturation is more than 50 percent and the soil ranges from medium acid at high elevations to moderately alkaline at the lower elevations on fans and terraces.

Mollisols are found mainly through the center of Utah from the Idaho border nearly to Arizona. They occur where average annual precipitation exceeds 12 inches and elevations are mainly above 5,000 feet. The exception is in the northern part of the state along the Wasatch Range where they occur at elevations of 4,400 to 5,000 feet. They primarily occur on lake terraces, alluvial fans, foothills, mountains, high plateaus, and valley bottoms. Mollisols are among some of the most important and productive agricultural soils. At higher elevations in Utah, they support rangeland, wildlife habitat, recreation, and timber, while at lower elevations, they support irrigated and non-irrigated cropland, rangeland, and wildlife habitat. Within the major Mollisol belt, local areas of Alfisols, Aridisols, Inceptisols, and Entisols are present.

LANDFORMS

Rock Outcrops – Rock outcrops consist of exposures of bare rock. Rock outcrops vary from the rocky summits of the Uinta Mountains and Wasatch Range to the sandstone outcrops typical of the Colorado Plateau, and from the bare surfaces along the Book and Roan Cliffs to the geologically recent lava flows on the High Plateaus. In all these areas, bare rock constitutes 50 to 75 percent of the surface, while shallow soils make up the remainder of the surface area. In Utah, national parks, national monuments, and several state parks are located in areas dominated by rock outcrops, many of which are spectacularly shaped and colored.

Dune Land – Several areas in the state have highly sandy soils and sediments, some of which are virtually devoid of vegetation. The sandy, bare surfaces are designated as dune land, and are composed of sand-sized particles that shift with the wind. Consequently, dunes typical of those found in the Sahara Desert or along ocean shores are formed. A plentiful sand source and strong prevailing winds in Juab County has created Little Sahara, one of the largest dune fields found in Utah. Most of the sand at Little Sahara National Recreation Area is the result of deposits left by the Sevier River. Coral Pink Sand Dunes in Kane County are another example of dune land in Utah.

Playas – Playas are dry or ephemeral lake beds that are typically remnants of internally drained lakes or systems. Playa sediments are fine grained and are often high in salinity. The playa areas in the Great Salt Lake Desert (Newfoundland Evaporation Basin) are characterized by intermittently wet areas, large expanses of salt pans or flats, and crystalline salt overlying stratified alkaline sediments. The Great Salt Lake Desert is the most extensive playa, but smaller playas, many of them containing salt flats, can be found elsewhere in the Lake Bonneville Basin. Playas are mostly devoid of vegetation, although some extremely salt-tolerant species, known as halophytes, may occur.

Badlands – Badlands are arid-land formations of softer sedimentary rocks and clay-rich soils that have been extensively eroded by wind and water. Badlands are typically accompanied by complex geological formations, including canyons, ravines, and gullies. The erosional processes and the geological formations tend to create irregular, jagged, fluted, and extraordinary landscapes. The term badland was first recorded by French-Canadian trappers who referred to a region of southwestern South Dakota (presently Badlands National Park) as *Les Mauvaises Terres a Traverser*, or the bad lands to cross. The term was later applied to other areas with similar eroded topography (Stevens et al., 2006). Portions of southern Utah are characterized by badland formations. Of notable interest are the Chinle Badlands formation in Grand Staircase-Escalante National Monument and the Mancos Shale badlands in Wayne County (Godfrey et al., 2008). Badlands are also commonly a source of rich fossil beds because erosion can expose the fossiliferous sedimentary layers (Stevens et al., 2006). Numerous fossiliferous badland formations exist in the United States, including those found at Dinosaur National Monument in Uintah County.

VEGETATION OF UTAH

R. Douglas Ramsey
Neil E. West

ECOSYSTEMS

In order to organize and facilitate management of Utah's ecosystems, generalization of the ecological variation found across the state is necessary. Ecosystems involve complex interactions between environment and biota, and there have been many efforts to generalize and categorize these interactions in order to gain a better understanding of their structure and organization. The most common method of categorizing ecological variations across large landscapes today incorporates the ecoregion concept. Ecoregions are geographic delineations of landscapes containing ecosystems linked by similar climatic, geologic, soil, and landform characteristics. The primary characteristics used to delineate ecoregions vary depending on the overall goal of the individual or management agency. Therefore, ecoregions vary in their geographic extent and shape, but tend to generally identify similar geographies and ecosystems. Examples of ecoregion delineations in Utah consist of the United States Forest Service Bailey Ecoregions (Bailey, 1995) and the Omernik Ecoregions used by the Environmental Protection Agency (EPA) (Omernik, 1987).

Bailey Ecoregions consist of a hierarchically nested set of units beginning with domains that are the most general and based on variations in climate. Utah falls entirely within the Dry Domain. Within domains are divisions that represent significant climatic variations. Within divisions, provinces are defined based on general natural vegetation cover, and within provinces, sections are defined by terrain features (Figure 7.1). Even within the lowest landscape unit, a section, there exists variation in environmental characteristics that can be further subdivided into progressively finer units. Ecoregions are therefore generally large geographic units of common climatic, vegetation, and landform characteristics that can have significant variation within. A clear example of this is the Henry and La Sal Mountains that have subalpine and alpine zones located within the Northern Canyon Lands Section of the Intermountain Semi-Desert and Desert Province of the Bailey Ecoregions.

Omernik Ecoregions (Figure 7.2), developed for the Environmental Protection Agency, were designed with the intent of generating regional biological criteria and water quality standards and setting goals for nonpoint source pollution. While the areas delineated as individual ecoregions in Omernik's map cover similar geographies to the Bailey delineation, there are significant differences. A major difference is that the Omernik Ecoregions are not hierarchically organized as are Bailey Ecoregions. Furthermore, while the Bailey Ecoregion delineations are based primarily on climatic and geologic differences, Omernik Ecoregions are focused on hydrology.

Levels of productivity and responsiveness to management vary greatly between different kinds of ecosystems and are evident across ecoregions. However, while ecoregions are applicable to regional and global applications, more local applications require a different approach in order to address ecoregion variances and understand differences between vegetation types. In order to distinguish between the kinds of ecosystems found in Utah, and communicate the major differences between them, the following cross-cutting classification system will be used. The major environmental gradient in Utah is climate, particularly precipitation and temperature, which are both highly correlated with elevation. Because of the great variation in elevation in Utah, the principal ecological distinction that has long been recognized is that of life zone. The nomenclature of the Natural Resources Conservation Service (NRCS) that identifies seven individual life zones will be used. The life zones, in order of descending elevation, are alpine, subalpine, high mountain, mountain, upland, semidesert, and desert.

The environmental characteristics that form the boundaries between each life zone tend to vary by user, but generally, there is agreement among land managers as to the individual characteristics of each. In general, precipitation increases and temperature decreases as deserts transition into the semidesert, upland, mountain, high mountain, subalpine, and alpine life zones. With a decrease in temperature as elevation increases, reference evapotranspiration (RET), which is defined as the amount of water that could be evaporated from the surface and transpired from plants, also decreases. The RET assumes that water is not limiting. Therefore, when RET is higher than precipitation, a net deficit in moisture occurs and conditions actually become drier. This relationship forms the general basis for the definition of life zones since water balance, in large part, determines the type and amount of vegetation that can occur in a given Utah environment. Since elevation, precipitation, and RET can be modeled spatially, these variables were used to spatially depict the distribution of life zones in Utah (Figure 7.3).

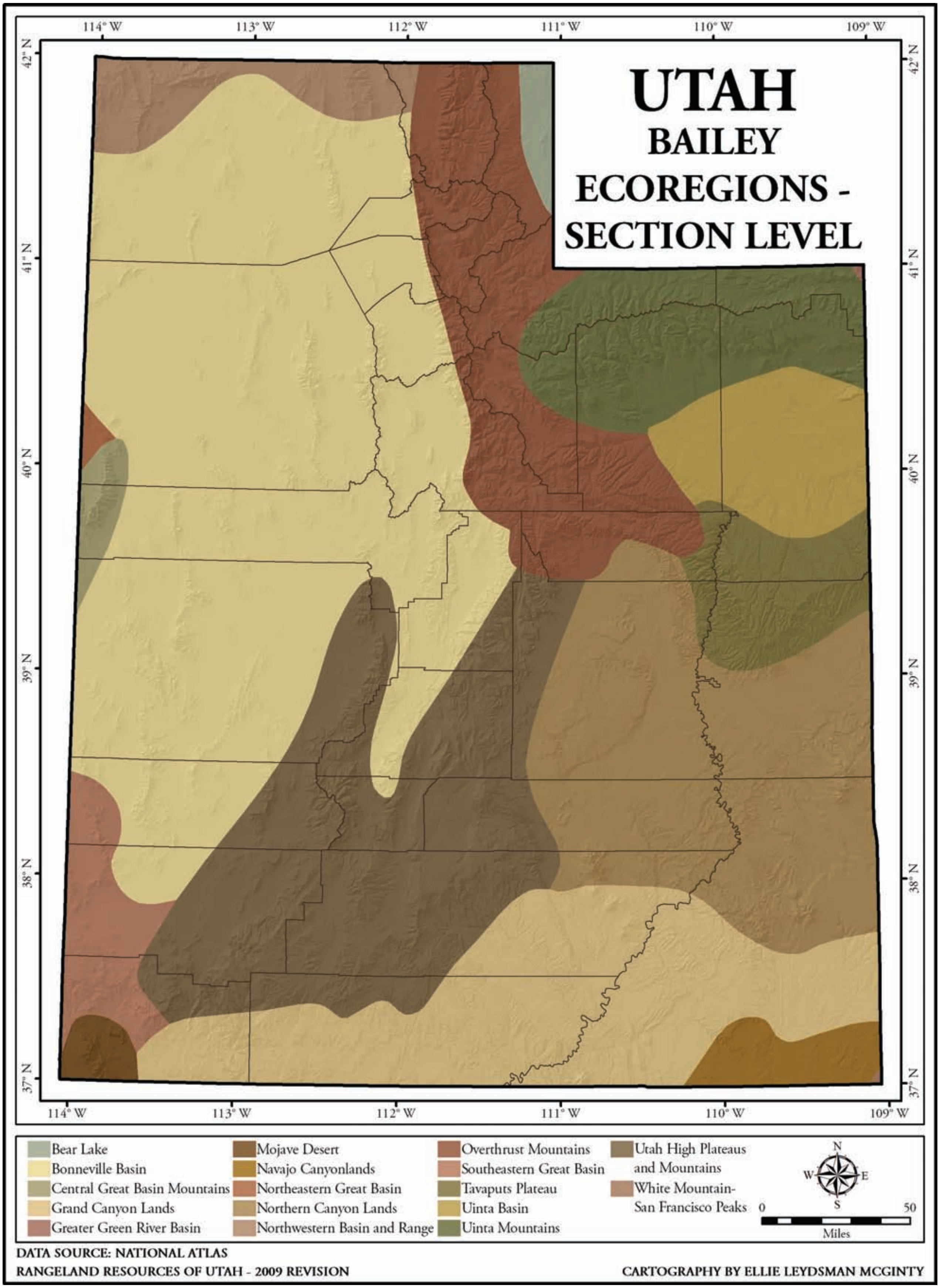


Figure 7.1. Bailey Section Level Ecoregions for Utah.

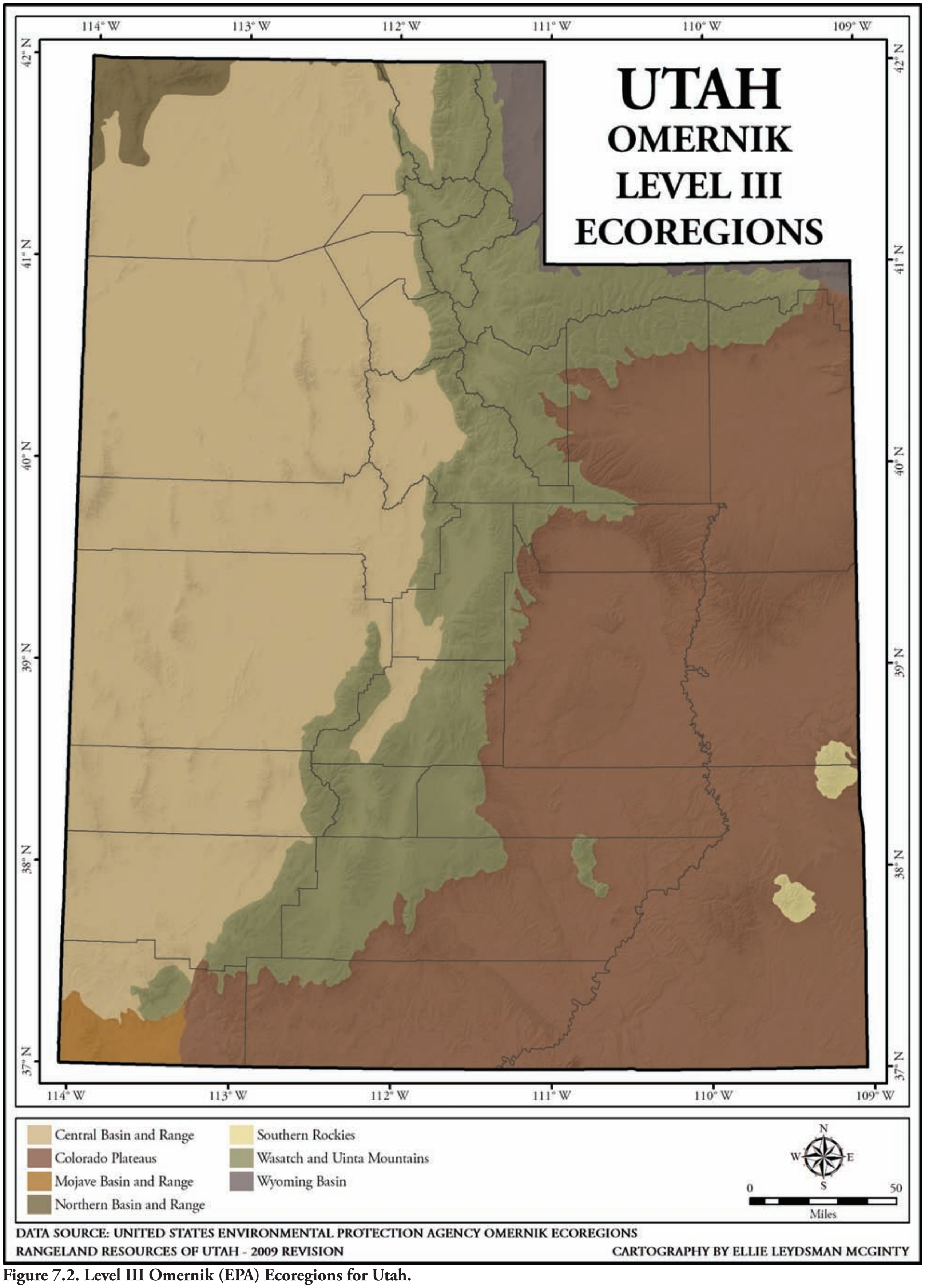


Figure 7.2. Level III Omernik (EPA) Ecoregions for Utah.

A shortcoming of the zonal approach is that some ecosystem types with unusual soils or hydrologic regimes do not easily fit. Examples are sand dunes, wet meadows, and marshlands which often occur in multiple life zones. Those that occupy large acreages or are unusually productive should be considered separately.

Because the efficiency of the precipitation that falls increases northward as average temperatures decrease, the altitudes of each life zone also decrease progressing northward. There is also considerable difference in the seasonality of precipitation from east to west. Accordingly, geography is included in the classification. To accomplish this, the Major Land Resource Areas (MLRAs) used by the NRCS were adopted (Figure 7.4). Those occurring in Utah and their percent occurrence in the state are:

MLRA	NAME	PERCENT
28A	Great Salt Lake Area	36.37
47	Wasatch and Uinta Mountains	23.38
35	Colorado and Green River Plateaus	19.57
34	Central Desertic Basins, Mountains, Plateaus	11.65
39	Arizona and New Mexico Mountains	2.12
48A	Southern Rocky Mountains	1.94
28B	Central Nevada Basin and Range	1.36
29	Southern Nevada Basin and Range	1.25
25	Owyhee High Plateau	0.93
30	Mohave Basin and Range	0.73
37	San Juan River Valley Mesas and Plateaus	0.50
13	Eastern Idaho Plateaus	0.11
43	Northern Rocky Mountains	0.09

It is often difficult when standing at a particular location to determine the life zone or MLRA. Elevations of the most appropriate zone for a given vegetation type vary considerably on different slopes and aspects of a given mountain. The plant indicator concept helps solve this problem. Plant species, particularly perennials, by their presence/absence and vigor, indirectly indicate a great deal about local effective environments. By using knowledge of these relationships, the relative abundances of particular plants can gauge the similarity of both adjacent and distant patches of land. In this way, vegetation becomes relatively easy to determine on the ground when transitioning into another kind of ecosystem. In the following, information is provided on how the most abundant (dominant) plants respond to various environmental conditions.

An individual could look across a landscape of interest, and by noting the repeating patterns of the vegetation, classify it into ecosystem types. This process has, however, already recently been done for Utah through the SWReGAP project (http://earth.gis.usu.edu/swgap) (Lowry et al., 2007). It is from this database that the acreages for each of the ecosystem types discussed in this document were derived.

The SWReGAP project subdivided the state into too many classes of vegetation to conveniently discuss here. Thus, they are aggregated into coarser vegetation types discussed within the zonal context (Figure 7.5). Table 7.1 shows where these coarser SWReGAP vegetation types fit in terms of life zone.

Primarily for reasons of simplicity, a brief consideration of ecosystem types at the highest elevations moving downward will be discussed. Consideration of the alpine zone will be first.

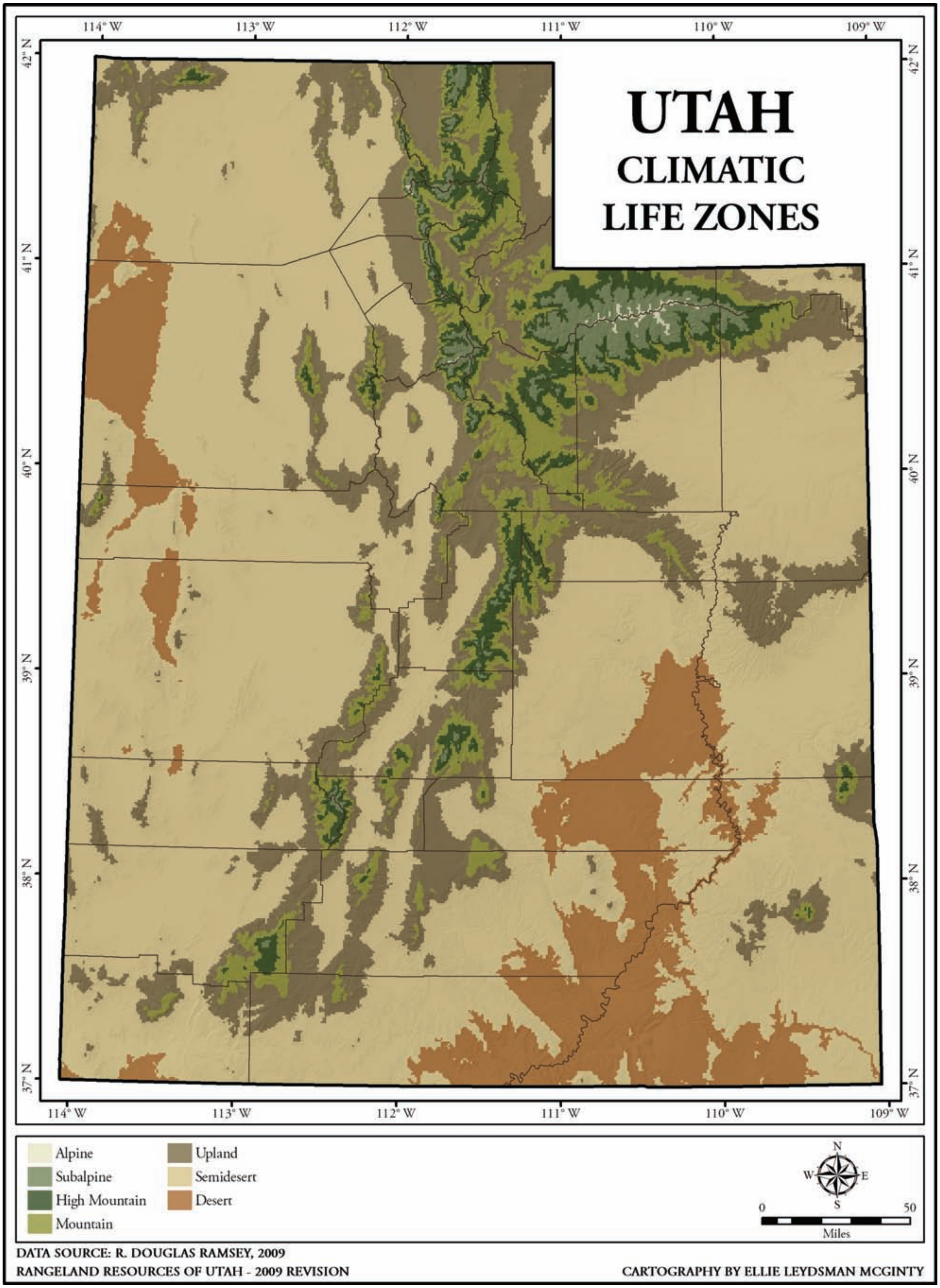


Figure 7.3. Major life zones derived from climatic factors.

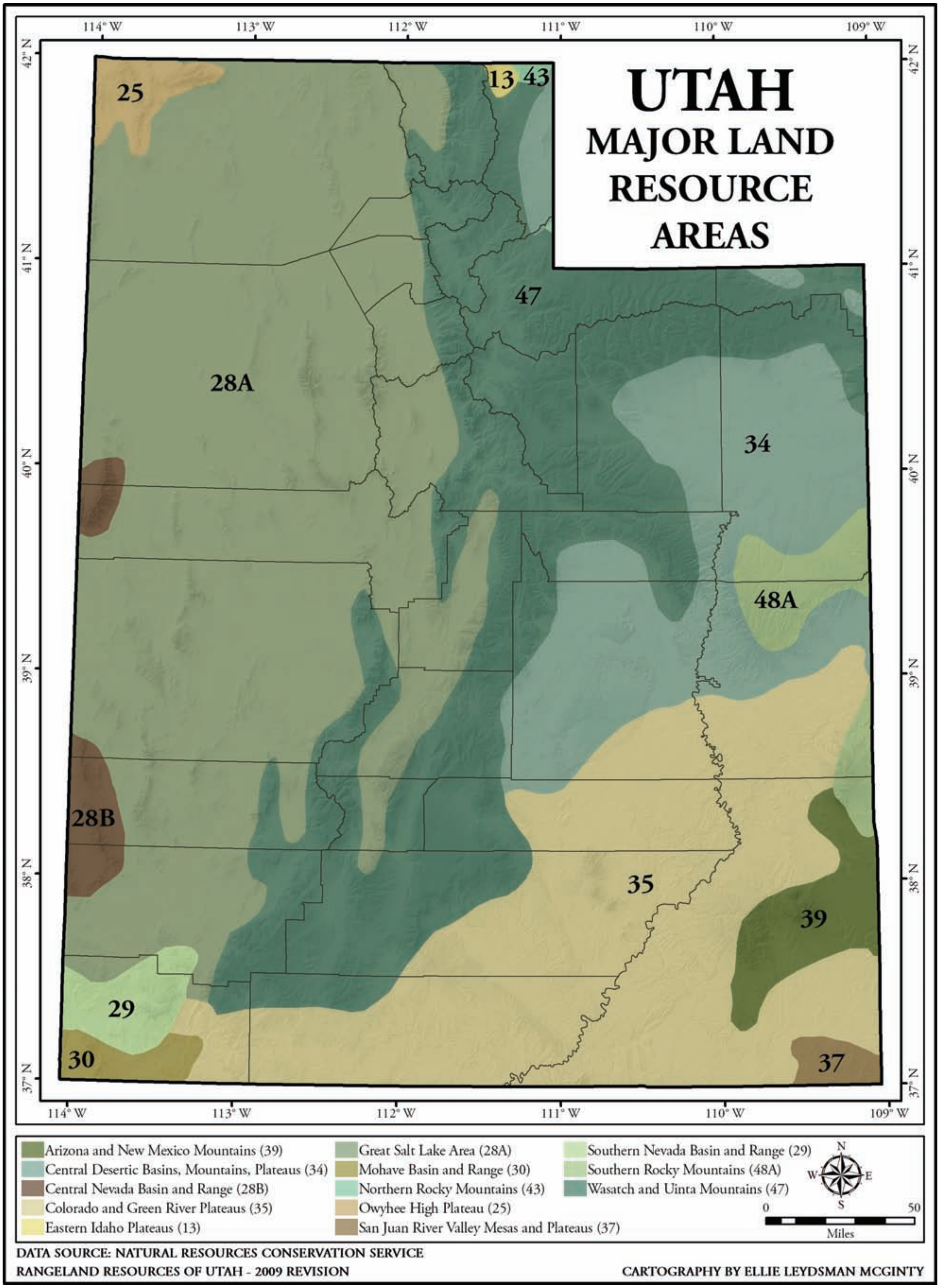


Figure 7.4. Major Land Resource Areas used by the NRCS to categorize large-scale ecosystems.

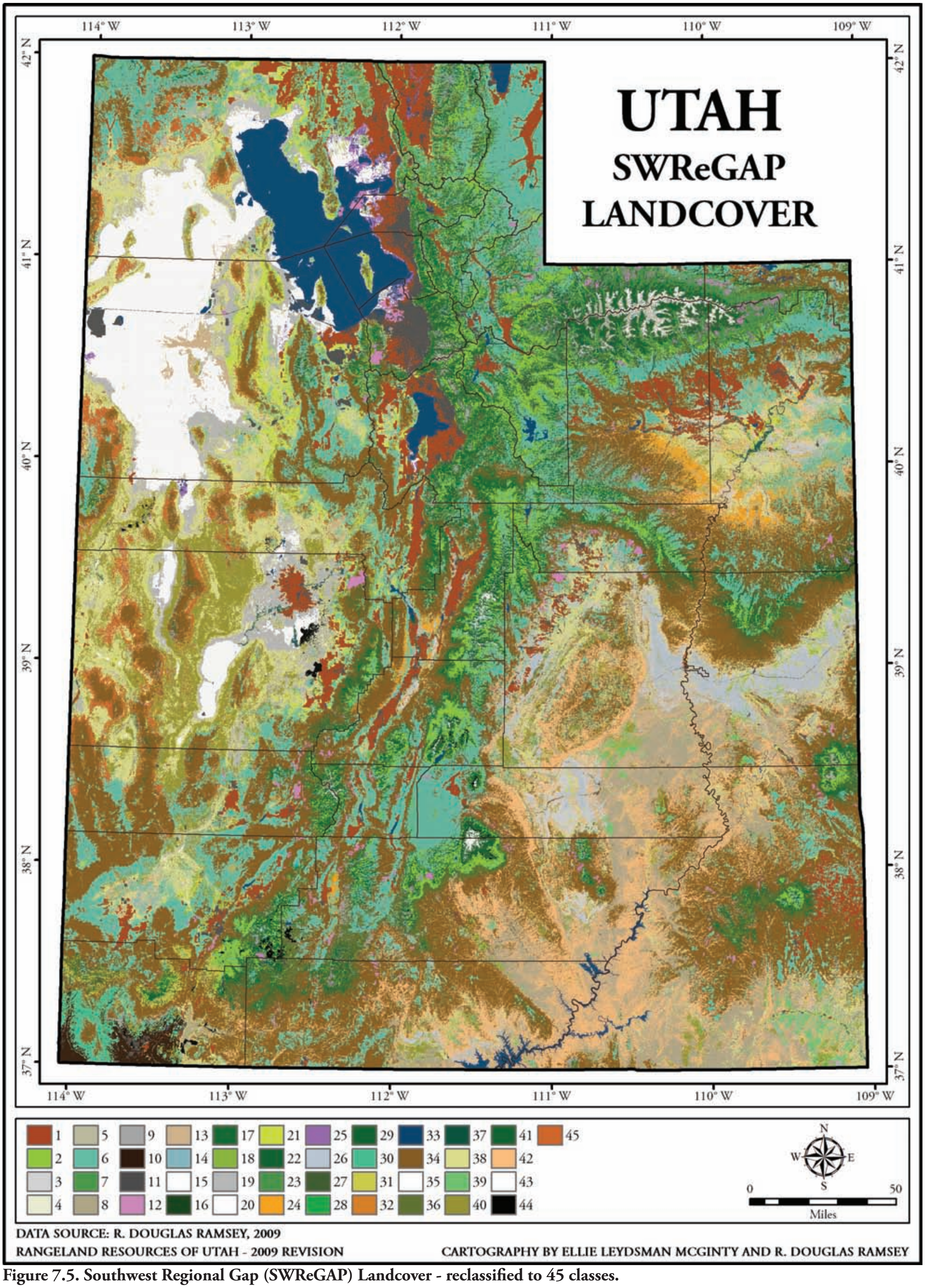


Figure 7.5. Southwest Regional Gap (SWReGAP) Landcover - reclassified to 45 classes.

Table 7.1. Percent occurrence of each cover type by life zone. Sum of percent of each cover type equals 100.

LEGEND	COVER TYPE	ALPINE	SUBALPINE	HIGH MOUNTAIN	MOUNTAIN	UPLAND	SEMI-DESERT	DESERT	ACRES
1	Agriculture				1%	24%	74%	1%	2,268,637
2	Aspen		4%	27%	47%	21%	1%		1,865,047
3	Badland						55%	45%	451,380
4	Barren Lands						67%	33%	10,551
5	Bedrock Scree	14%	69%	13%	3%	1%			201,263
6	Big Sagebrush		1%	3%	11%	31%	54%		8,507,705
7	Bigtooth Maple		4%	20%	48%	27%	1%		218,765
8	Blackbrush-Mormon Tea						37%	63%	2,242,282
9	Cliff and Canyon		8%	7%	11%	34%	40%		488,546
10	Creosote-White Bursage						65%	35%	202,209
11	Developed				3%	35%	55%	7%	765,031
12	Disturbed		1%	11%	15%	24%	49%		303,644
13	Dune						39%	61%	447,263
14	Dwarf Shrub	8%	91%	1%					27,035
15	Fell Field	13%	86%	1%					43,621
16	Foothill Shrub				2%	86%	12%		62,160
17	Oak			4%	26%	62%	8%		1,631,329
18	Grassland			1%	5%	17%	65%	12%	643,784
19	Greasewood						88%	12%	1,805,404
20	Ice Field	61%	39%						5,239
21	Invasive				1%	7%	84%	8%	1,213,659
22	Limber-Bristlecone Pine		27%	17%	42%	14%			17,280
23	Lodgepole Pine		14%	43%	35%	8%			448,230
24	Low Sagebrush					2%	98%		375,728
25	Marsh					24%	69%	7%	118,848
26	Mat Saltbush						68%	32%	749,958
27	Meadow	1%	35%	30%	16%	12%	6%		241,362
28	Mesquite						34%	66%	756
29	Mixed Conifer		2%	10%	32%	45%	11%		774,468
30	Mixed Shrub		1%	10%	32%	45%	12%		203,321
31	Mogollon Chaparral				3%	46%	51%		143,194
32	Mountain Mahogany		1%	10%	34%	49%	6%		153,943
33	Open Water				2%	7%	81%	10%	1,663,042
34	Pinyon-Juniper				1%	24%	75%		10,567,696
35	Playa						66%	34%	2,787,471
36	Ponderosa Pine				7%	67%	26%		500,466
37	Riparian		2%	7%	13%	22%	53%	3%	365,718
38	Salt Desert Shrub						90%	10%	3,829,998
39	Sand Shrubland						58%	42%	212,370
40	Shrub Steppe						92%	8%	2,056,220
41	Spuce-Fir		26%	33%	28%	13%			1,111,750
42	Tableland					1%	57%	42%	3,513,036
43	Tundra	7%	46%	23%	24%				72,425
44	Volcanic Rockland			12%	19%	12%	56%	1%	80,394
45	Xeric Sagebrush					4%	96%		888,915
	TOTAL								54,281,146

ALPINE ZONE

The alpine zone occurs in high mountain areas where the mean annual precipitation is above 41 inches and the RET is the lowest in the state (Figure 7.6). These areas occur above the upper timber line. The vegetation consists mainly of small cushion plants on rocky slopes. Elevation ranges from 10,800 feet to 13,528 feet above sea level (ASL). Snow tends to persist in these areas most of the year, and in some areas, snow pack does not disappear, depending on topography and the year.

The climate is characterized by long, cold winters and short, cool growing seasons of less than 60 days (Figure 7.7). Even then, frost can occur at any time. Although total annual precipitation is usually over 40 inches, soil water is often in frozen form because the mean annual temperature is well below 32 degrees Fahrenheit.

Much of the alpine zone is comprised of steep, barren and exposed bedrock or loose scree and fell fields (72 percent). Some of this is permanent snow and ice (7 percent). Soils usually develop between rocks and in pockets of gentler terrain where fine particles accumulate (Photographs 1 and 2).

The alpine zone in Utah occupies about 50,650 acres, of which only about 16 percent is well vegetated (Table 2). The Uinta Mountains have the most area at these elevations, but the Wasatch, Tushar, Deep Creek, and La Sal mountains also have smaller true alpine areas.

Tundra plants are all low growing due to the mean cold temperature and frequent high winds. Perennial herbs, especially grass-like sedges, prostrate shrubs, mosses, and lichens share dominance. Alpine vegetation is characterized by a patchwork of many different plant communities. Individual stands of relatively homogeneous turf may occupy only a few square yards and seldom exceeds 20 acres. The boundaries between communities vary from abrupt to diffuse, with the latter case being more common (Photographs 3 and 4).

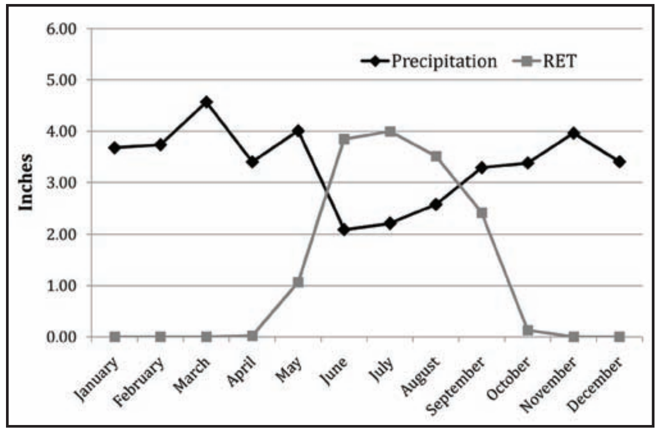


Figure 7.6. Monthly distribution of precipitation within the alpine zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

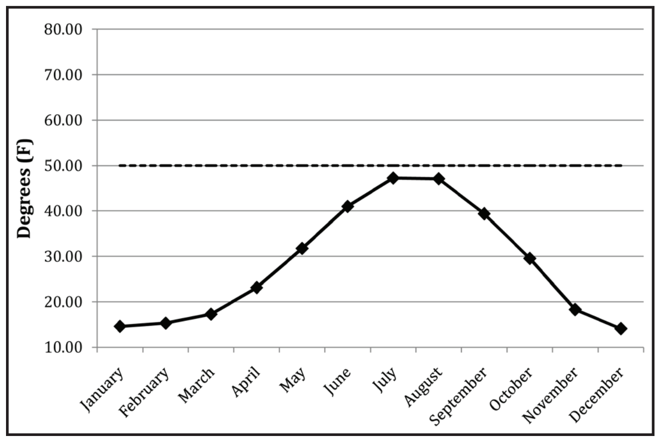


Figure 7.7. Average monthly temperatures within the alpine zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.2. Distribution of generalized SWReGAP land cover types across the alpine zone in Utah.

LANDCOVER	ACRES	PERCENT
Bedrock Scree	27,901	60
Fell-Field	5,861	12
Tundra/Meadow	5,399	16
Ice Field	3,210	7
Dwarf Shrub	2,293	5
TOTAL	48,391	100

The amount of soil moisture available during the growing season is the main factor that determines which plant species will be found in a particular stand. Aspect, slope, and wind exposure control snow distribution and timing of melting (Figure 7.8). Aboveground plant production and forage availability can vary greatly between points only a few yards apart. The most productive sites are those with moderate amounts of soil moisture. Less productive are the tarns centered around small ponds. The least productive locations are freely drained rocky ridges exposed to desiccating winds and places where the lingering snowpack results in too short a growing season for much of any vascular plant development.

Ten to 15 species constitute the bulk of the plant cover in the Uinta Mountains (Lewis, 1970). A rosaceous forb, Ross' Avens (*Geum rossii*), is the most common. The sedge *Carex scirpoidea* was found in about half of the locations sampled by Lewis (1970); tufted hairgrass (*Deschampsia caespitosa*) was found in both dry and wet meadows. Lewis (1970) recognized five plant communities distinguished by the following dominant species:

Cushion Plant: *Silene acaulis*
Paronychia pulvinata
Minuartia obtusiloba
Trifolium nanum
Carex rupestris

Dry Meadow: *Geum rossii*
Carex rupestris
Carex scirpoidea
Carex elynoides
Kobresia myosuroides
Deschampsia caespitosa

Wet Meadow: *Deschampsia caespitosa*
Polygonum bistortoides

Bog: *Carex aquatilis*
Eriophorum chamissonis

Shrub Thicket: *Salix planifolia*
Salix glauca
Salix drummondiana

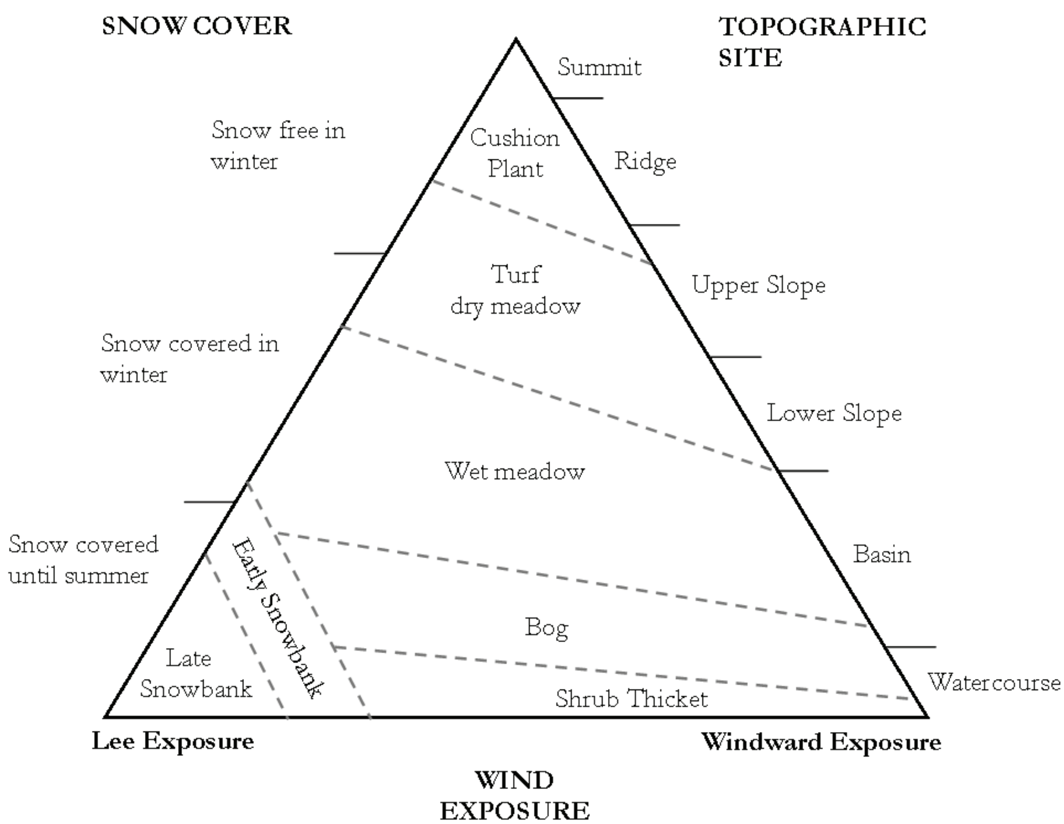


Figure 7.8. Relationship of alpine plant communities to snow cover, wind exposure, and topographic site (from Thilenius, 1975).

Plant cover varies enormously between these community types with the least cover on the dry, windswept ridges, tarns, and centers of the deepest snow drifts on the lee slopes. There can be near 100 percent cover in the sub-irrigated meadows.

Total herbage production can vary from almost nothing on scree slopes to over 2,500 pounds per acre around the bogs. On intermediate sites, production will vary from 700 to 1,600 pounds per acre. However, these figures can vary as much as 50 percent from year to year, depending on growing season conditions. Aboveground primary production usually peaks 3 to 4 weeks after snowmelt (mid-July), then slowly declines (Figure 7.9). Because nearly all the aboveground tissues die after each growing season, phytomass is similar to annual primary production in most communities. The major difference is the flowering buds that are preformed 2 to 3 years in advance of their expansion (Thilenius, 1975).

While not always easily seen, wild animals are relatively abundant in the alpine zone. Many mammals utilize the alpine ranges for summer habitat, while others may be resident throughout the year. Among the common year-long resident mammals are shrews, pikas, hares, marmots, pocket gophers, deer mice, voles, weasels, and mountain goats. Because of its soil-disturbing activities, the most influential tundra mammal is the pocket gopher. These animals bring large quantities of soil to the surface where strong winds and water runoff can move it downslope. They also consume considerable herbage, focusing on fleshy-rooted forbs. Large native mammals using the alpine zone primarily as summer habitat include elk, mule deer, coyote, red fox, black bear, bobcat, and badger. Moose occasionally enter the alpine zone. Smaller summertime resident mammals include porcupine, marten, chipmunks, and ground squirrels.

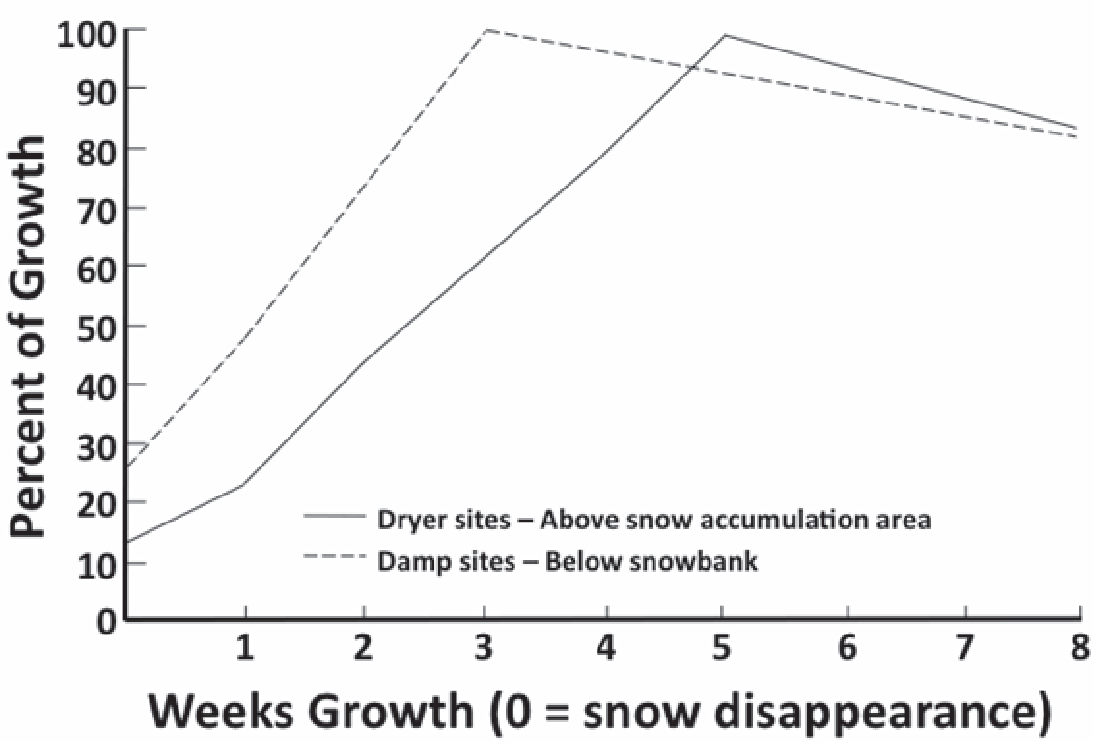


Figure 7.9. Growth curves of alpine plants (from Lewis, 1970).

Many birds use the alpine zone, but the most characteristic species is the ptarmigan that is present yearlong. In summer, the water pipit, rock wren, rosy finch, raven, and several eagles and hawks are present. See Hayward (1952) for a listing of the invertebrates found in the alpine zone of the Uinta Mountains.

Determination of rangeland condition and trend requires special considerations for alpine rangelands. Rather than marked changes in species composition, the changes occurring due to heavy livestock grazing appear as a "wearing out" process (Lewis, 1970). That is, plants are thinned out, reduced in vigor, and soil erosion accelerates. Once an area has been disturbed, upward trend in condition is slow to materialize. Grazing impact studies (Lewis, 1970) show that serious erosion problems develop when about 30 percent of the soil becomes bare.

Primary succession is exceedingly slow in such environments, although several authors have described the *Kolbresia-Carex* meadow on well-drained, deeper soils as the climatic climax. This notion is of little practical value because of the geologic time scale required to think about it. Retrogressional and secondary successional phenomena are much more important. In addition to natural influences such as wind, water, and frost in breaking down vegetation and soils, the possible impact of native animals, humans, and domestic livestock must be considered.

Aboriginal people hunted and gathered during the late summer on the alpine tundra of Utah. Europeans apparently did not visit them much until the present century. The major modern use has been by herded domestic sheep. Overstocking and lack of management has been common in the past on the more accessible parts of the Uintas. Creation of the forest reserves early in the twentieth century resulted in most of the alpine zone becoming managed by the United States Forest Service. Protection of headwaters and watersheds became the first priority. Most of the alpine zone in Utah was designated official wilderness in the 1970s. Only small areas patented under mining law are currently in private ownership and usually occupied by ski-oriented resorts. The lack of motorized access to most of this zone has resulted in relatively little current grazing by domestic livestock.

Revegetation in such environments is very difficult. The alpine environment is so rigorous that there are not any invasive species. Also, there are not any exotics that are easily reseeded. The alpine zone will have to rely on the native pioneers, such as alpine avens and other forbs, to heal the scars from past use. The greatest resource of the alpine zone to all citizens is its role in providing stream flow in late summer and fall when lower zones provide little to none. Unfortunately, global climate change threatens the extinction of these zones in the longer run.

SUBALPINE ZONE

The mean annual precipitation of the subalpine life zone ranges between 31 and 40 inches, with a strong surplus of water given a relatively low annual RET (Figure 7.10). These environments are located just below the upper tree line. Where not excessively steep or rocky, the subalpine zone is vegetated by conifers, aspen, and meadows. Elevations of this zone range between 8,900 feet and 11,000 feet ASL. Plant and animal diversity is somewhat lower than the high mountain zone, since mean annual temperatures tend to be fairly cold, driving much of the wildlife to lower elevations for much of the year. Snow tends to persist in these environments for much of the year save the 3 to 4 months of summer.

According to the SWReGAP generalized land cover dataset, dominant land cover is distributed among a number of cover types, but consists primarily of spruce-fir communities and bedrock scree (Table 7.3). Less expansive types, such as meadow, aspen, lodgepole pine, and mountain big sagebrush, are also commonly found within this zone. While spruce-fir communities occupy a majority of the subalpine zone, the bulk of the spruce-fir type is predominantly found in the high mountain zone and will be discussed in more detail in that zone. The subalpine zone is dominantly located within the Wasatch and Uinta Mountains MLRA with very small proportions (1 percent or less) in the Great Salt Lake Area and Eastern Idaho Plateaus MLRAs.

Forested sites that have been undisturbed by fire for long periods are dominated by coniferous trees [spruces (*Picea engelmannii*, *Picea pungens*) and true firs (*Abies lasiocarpa*, *Abies concolor*)] that are rarely continuous. Intermingled meadows are an important part of the zone, as are the stringers of scraggly, long-lived, five-needled pines (*Pinus flexilis*, *Pinus longaeva*, and *Pinus aristata*) that occupy rocky ridges. Open woodlands of either aspen (*Populus tremuloides*) or lodgepole pine (*Pinus contorta*) occur on sites that have been disturbed by fire within the past 100 years. Thus, the subalpine zone has everything from open meadows dominated by herbaceous vegetation to open woodlands or dense forest depending on a combination of site conditions and disturbance history. The common denominators are the heavy winter snowpack, cool summer temperatures, and short growing season (Figure 7.11).

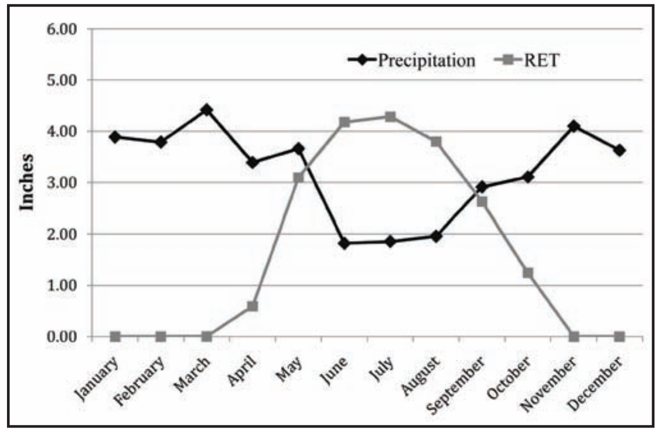


Figure 7.10. Monthly distribution of precipitation within the subalpine zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.3. Distribution of generalized SWReGAP land cover types across the subalpine zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Spruce-Fir	288,989	32
Bedrock Scree	138,651	15
Subalpine Meadow	117,166	13
Aspen	66,959	7
Lodgepole Pine	64,513	7
Subalpine Big Sagebrush	63,045	7
Miscellaneous	165,286	18
TOTAL	904,608	100

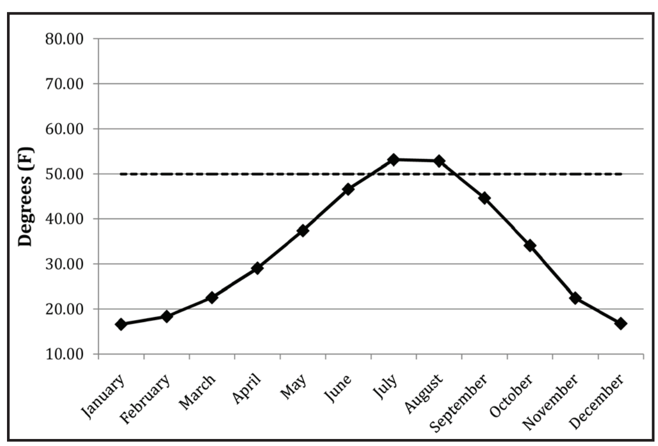


Figure 7.11. Average monthly temperatures within the subalpine zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Commercial harvest of forest products from the subalpine zone takes place, but at a much reduced level from historical practice. Van Hooser and Green (1983) rank only half of the subalpine forests as commercial.

The high water yield (in excess of an average of 8 inches per year) from deep snowpacks makes this zone extremely important as watersheds, even if no other products are harvested from the land. It should not be surprising that logging and livestock grazing are excluded from a considerable portion of the zone identified as critical watersheds. Another large fraction is concomitantly wilderness where non-motorized recreation is the only permitted use. Most recreational use is centered on backpacking and fishing, although winter skiing and snowmobiling regularly occur.

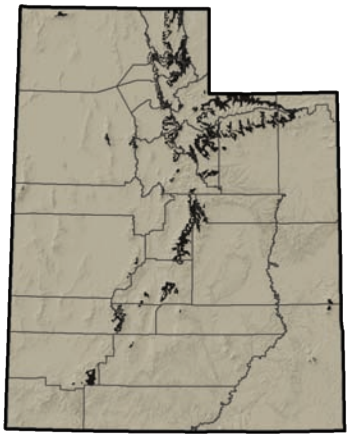
The boundaries between community types are usually abrupt because trees develop distinctly different microclimates under their canopies. How much of the mosaic is due to inherent differences in physical and chemical site factors as opposed to biological or mediated changes due to competition and succession has been widely debated. For instance, the existence of meadows has been variously attributed to disturbance by fire, cold air drainage, impeded water tables, fine-textured soils, competition of the herbaceous vegetation with tree seedlings, pocket gopher disturbance, and differential snowpacks. Each of these causes could be controlling in particular circumstances. Normally, causes are interlinked, making simple cause-effect assessments unrealistic. Interpretation of the interplay of environmental factors with successional pathways is, however, important to the land manager.

The flora of the subalpine zone is rich in species, if all habitats and successional stages are considered. Reese (1981) found an average of 182 higher plant species in a cross section of the subalpine zone on 4 square miles of northern Utah. Forbs are more numerous than grasses. Perennials are much more common than annuals. Shrubs, such as Oregon boxleaf (*Paxistima myrsinites*), found on basic soils, or huckleberry (*Vaccinium* spp.) found on acid soils are few in number and only patchily dominant in terms of cover or weight. There is usually a very pronounced week-to-week change in conspicuousness of herbaceous species during the growing season as the various species grow, flower, and set seed at different times (Reese, 1981).

The spruce-fir association, typical of undisturbed forested sites in the zone, usually has very sparse understory vegetation covering less than 5 percent of the surface. If the sites have been disturbed since the advent of Europeans, the forest is very likely to be an open woodland with a dense understory population of grasses and herbs. The most important portion of the subalpine zone from the ungulate grazing standpoint is the mixed upland herb communities, or open meadows. The ephemeral community is dominated by plants that die in midsummer. These are usually annuals of low grazing value. Unfortunately, much of the subalpine zone has had its productivity limited in the past by excessive grazing and consequent erosion. While livestock use has been reduced in recent decades, the impact from increased elk has not necessarily led to improved rangeland conditions. In fact, while livestock use is required to abide by range readiness guidelines, elk do not. The result is often patches of early heavy utilization by elk before livestock are allowed on. The net result is a lowered condition of those rangelands. Cooperation between land management agencies and the Utah Department of Wildlife Resources will be required to mitigate these problems.

Certain cover types mentioned here straddle several zones. In particular, meadow, aspen, lodgepole pine, and sagebrush in the subalpine zone are encountered. Fuller consideration of the cover types that compose their highest fraction of contribution to a zone will be deferred. Thus, for instance, spruce-fir and lodgepole pine communities will be discussed in the high mountain zone and aspen will be discussed in the mountain zone.

HIGH MOUNTAIN ZONE



The high mountain zone occurs just below the subalpine zone, at approximately 7,800 to 10,000 feet in elevation. This zone occupies 1,792,646 acres or 3.3 percent of the state, and is widely distributed along the central mountain spine going down the middle north-south axis and around the Uinta Mountains. The climate in the high mountain zone is cool and sub-humid. Reference evapotranspiration (RET) exceeds precipitation for approximately 5 months centered on summer (Figure 7.12). This zone relies on a significant amount of snowfall and slow melt during spring, leading to soil moisture lasting into the summer months to sustain vegetation growth. Summers are warm and dry in the north, but have a period of convectional showers, particularly to the south. Mean annual precipitation ranges from a high of 13.2 inches during winter (December to March) to a low of 5.5 inches in summer (July to September). Total mean annual precipitation when all months are considered is 32.3 inches. Mean annual temperatures vary from 21 degrees Fahrenheit during the winter to 54 degrees Fahrenheit during the summer. The growing season based on agricultural norms of consecutive days above 50 degrees Fahrenheit normally begins the first of June and extends until the latter part of August (Figure 7.13).

The topography within this zone varies from steep rocky peaks, slopes, and ridge tops to plateaus or gently sloping meadows. The soils range from Entisols in the former to Inceptisols and Mollisols in the latter.

The vegetation within this zone involves a diversity of forms from forests (63 percent), low shrublands (16 percent), tall shrublands (6 percent), and meadows (4 percent). While Table 7.4 shows that the top four major land cover types within this zone consist of aspen, spruce/fir, big sagebrush, and lodgepole pine, the distribution of these types across life zones shows a different story (Table 7.1). Aspen is found primarily in the mountain zone, and big sagebrush has only a minor component in the high mountain. As far as the high mountain zone is concerned, its small distribution across the state (3.3 percent) as a narrow band between the mountain and subalpine enforces

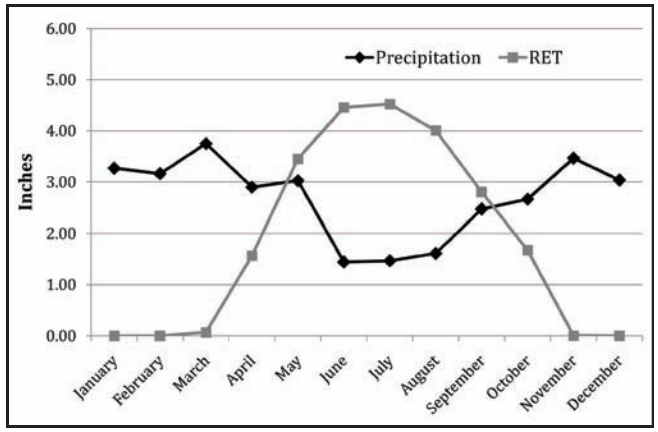


Figure 7.12. Monthly distribution of precipitation within the high mountain zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

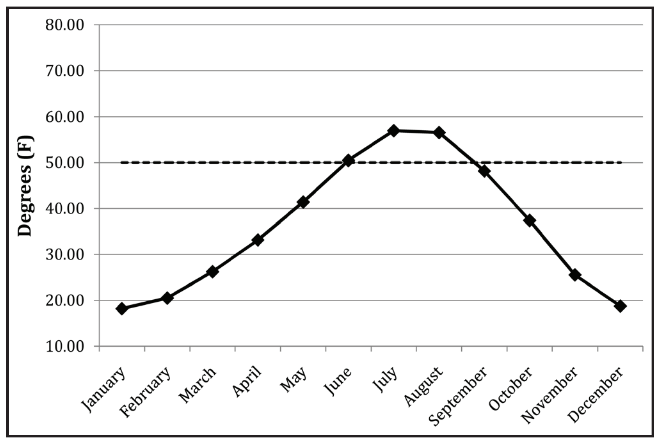


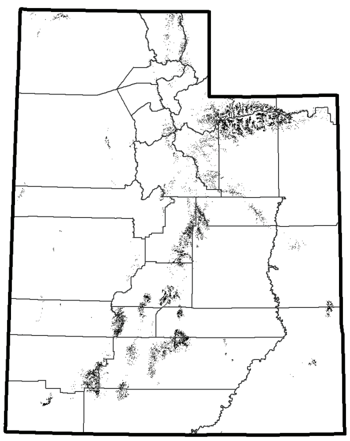
Figure 7.13. Average monthly temperatures within the high mountain zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.4. Distribution of generalized SWReGAP land cover types across the high mountain zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Aspen	510,720	28
Spruce-Fir	362,651	20
Big Sagebrush	291,733	16
Lodgepole Pine	190,697	11
Mixed Conifer	73,908	4
Meadow	72,286	4
Oak Brush	63,067	4
Bigtooth Maple	42,705	2
Miscellaneous	184,840	10
TOTAL	1,792,607	100

its role as an ecotone (zone of transition) between the next higher and next lower zone. The two major components of spruce/fir forest and lodgepole pine, which show dominance in the high mountain zone, will be considered in more detail in this section. The high mountain zone is found predominantly in the Wasatch and Uinta Mountain MLRA (93 percent) with a 4 percent component in the Great Salt Lake Area MLRA. The remainder of this life zone is spread among MLRAs that have mountain "islands" within areas largely occupied by lower elevation life zones.

SPRUCE-FIR COMMUNITIES



Engelmann spruce and fir forests often represent the highest elevation forests in an area. The area covered by this type occurs across all life zones for a total of approximately 1.1 million acres. Most of it is found from the mountain to subalpine zones, with a slight majority occurring within the high mountain zone (Figure 7.14; Photograph 5). Tree canopies commonly consist of Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) dominating either mixed or alone. Blue spruce (*Picea pungens*) is common in the most southerly locations and spruce, being slower growing, is found largely where fire has been absent for a longer period of time. Douglas fir (*Pseudotsuga menziesii*) may persist for long periods without true fir or spruce regeneration. Lodgepole pine (*Pinus contorta*) is common in many places, and patches of pure lodgepole pine are not uncommon, as well as mixed conifer/quaking aspen (*Populus tremuloides*) stands where fire has been most frequent. There are two basic versions of this ecosystem, xeric (dry) and mesic (moist) types. Xeric understory species may include common juniper (*Juniperus communis*), twinflower (*Linnaea borealis*), creeping barberry (*Mahonia repens*), or grouse whortleberry (*Vaccinium scoparium*). Mesic variants show more sedges (*Carex* spp.) and forbs.

The mesic variant of this type occurs typically in locations with cold-air drainage or ponding, or where snowpacks linger late into the summer, such as north-facing slopes and high-elevation ravines. These variants can extend into the subalpine zone on drier sites and also down into the mountain zone in places where cold-air ponding occurs; northerly and easterly aspects predominate. The xeric variant forests are found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, plateau-like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. Mesic understory shrubs include thinleaf huckleberry (*Vaccinium membranaceum*), Saskatoon serviceberry (*Amelanchier alnifolia*), thimbleberry (*Rubus parviflorus*), and willow (*Salix* spp.). Herbaceous species include forbs, such as red baneberry (*Actaea rubra*), starry false lily of the valley (*Maianthemum stellatum*), sprucefir fleabane (*Erigeron eximius*), and yellowdot saxifrage (*Saxifraga bronchialis*). A common grass is bluejoint (*Calamagrostis canadensis*). Disturbances include occasional blow-down, insect outbreaks and stand-replacing fire.

Prior to the migration of Europeans to these landscapes, disturbance regimes typically consisted of fires, insects, disease, and herbivory from native animals. These impacts maintained a diversity of stand conditions. Following settlement by Europeans, additional impacts consisted of logging and grazing. The suppression of fire has also impacted these types by creating dense, even-aged stands that connect to each other in space. This connectivity between stands increases the risk of very large wildfires in contrast with wildfires that occurred before fire suppression. The lack of stand size and age class diversity also increases the potential for devastating attacks by insects and pathogens including the mountain pine beetle, which can and has killed large tracts of these forests. This larger scale impact by pathogens also increases the chance of stand-replacing wildfires by providing large tracts of dead and dry timber.

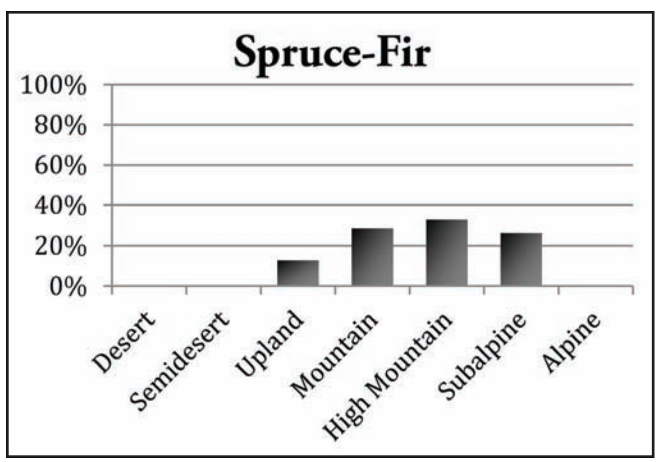
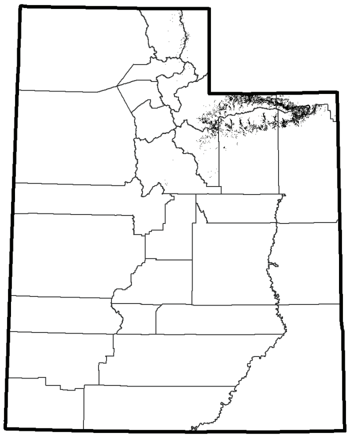


Figure 7.14. Distribution of spruce-fir communities across life zones.

LODGEPOLE PINE COMMUNITIES



There are more than 440,000 acres of this community type across Utah spanning the mountain through subalpine zones, with a modal occurrence in the high mountain zone (Figure 7.15). These forests are closely related to fire history and topoedaphic conditions. Following stand-replacing fires, lodgepole pine will rapidly colonize and develop into dense, even-aged stands, but usually are re-burned before an even-age class structure has developed. Most of these forests are found particularly on sites that are too extreme for other conifers to establish. These include excessively well-drained pumice deposits, glacial till, and alluvium on valley floors where there is cold air accumulation, warm and droughty shallow soils over fractured quartzite bedrock, and shallow moisture-deficient soils with a significant component of volcanic ash. Soils supporting these forests are typically well drained, gravelly, coarse-textured, acidic, and rarely formed from calcareous parent materials. Understory production is low to none in mature stands, but open, immature stands support a variety of shrubs and grass (Photograph 6). Sometimes there are intermingled mixed conifer/aspen stands with the latter occurring with inclusions of deeper, typically fine-textured soils (Photograph 7). Common understory shrub species include kinnikinnick (*Arctostaphylos uva-ursi*), snowbrush ceanothus (*Ceanothus velutinus*), twinflower (*Linnaea borealis*), creeping barberry (*Mahonia repens*), antelope bitterbrush (*Purshia tridentata*), Russet buffaloberry (*Shepherdia canadensis*), dwarf bilberry (*Vaccinium caespitosum*), grouse whortleberry (*Vaccinium scoparium*), thinleaf huckleberry (*Vaccinium membranaceum*), mountain snowberry (*Symphoricarpos oreophilus*), and currant (*Ribes* spp.).

European men began exploiting forested lands in the mid- to late-1800s with significant extraction of timber for building projects in growing settlements. This led to significant denudation of forests and general land degradation. With the creation of the first forest reserve in Utah (the Uinta Forest Reserve in 1897), these landscapes came under additional management to protect watershed and timber resources. The combination of excessive logging and grazing by domestic livestock caused significant erosion and subsequent loss of range and forest productivity, as well as impacts to water quantity and quality.

During the latter part of the 20th century, grazing was significantly reduced and timber harvesting more tightly managed. With the growth and development of towns and cities along the Wasatch Front, extractive industries have seen increased competition by recreational and leisure industries, which rely on viewshed quality. These two industries, in combination with the need for increased watershed management to provide water to a growing population, pose significant challenges to the Forest Service. The Forest Service must find a balance of multiple uses while maintaining forest health.

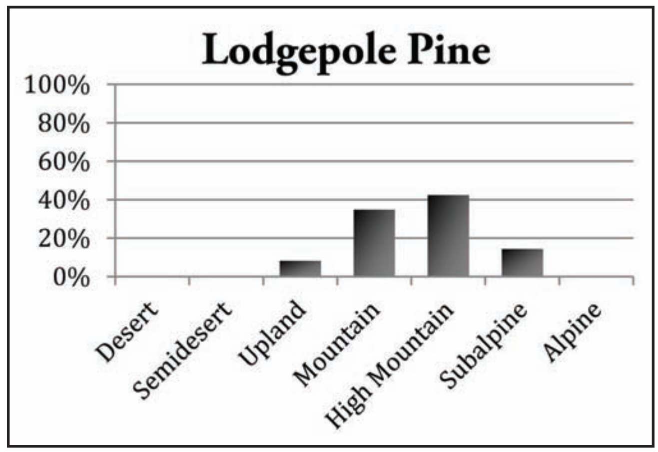


Figure 7.15. Distribution of lodgepole pine communities across life zones.

The state of Utah is not a major timber producer when compared to regions to the northwest and southeast. In fact, Utah has been a net importer of lumber since 1880 to support rural and urban development. With the majority of timber extraction restricted to private lands, the ability of this industry to support local sawmills has decreased significantly. The lack of locally accessible sawmills reduces profits for landowners and further reduces timber harvesting. While some laud the reduction of timber harvest in the state, the net effect may be an overall loss in landscape diversity, wildlife habitat, changes in fire intervals and intensity, and a loss in water yield. During the settlement period of the 1800s, mean fire intervals decreased (increased number of fires per unit time) due to an increase in combustion sources (accidental ignition by humans) (Wadleigh and Jenkins, 1996). This activity created landscape mosaics of different land cover. As fire suppression activities came into vogue after the start of the United States Forest Service in 1905, mean fire return intervals increased (fewer fires per unit time) when compared to pre-settlement conditions. This increase in mean fire return interval reduced general landscape diversity. Shade-intolerant species, such as lodgepole pine and aspen, have given way to the more shade-tolerant subalpine fir. A decrease in forest stand spatial diversity increases the chance of larger catastrophic fires. The need, therefore, is to somehow balance management activities to maintain these forests in a healthy and diverse condition.

Mature lodgepole pine communities do not provide significant forage habitat for domestic or wild grazers. The relatively closed canopy limits sunlight penetration to the forest floor, thus reducing understory production by grasses, forbs, and shrubs. This denser forest, however, does provide significant thermal and hiding cover for wildlife that forage in adjacent plant communities. Elk and deer use lodgepole pine communities during summer when snow has receded or melted completely (USU Extension, 2009).

There are a number of insect pathogens that impact these communities. These include the lodgepole terminal weevil, pandora moth, and the needle miner. While they slow production and may kill some trees within a stand, they do not significantly impact the entire stand (Amman, 1975). However, the mountain pine beetle (*Dendroctonus ponderosae*) can significantly impact entire stands by attacking the larger diameter trees with thick phloem layers. Since lodgepole pine communities tend to be relatively even aged, beetles can kill entire stands. Management to reduce the impact of the mountain pine beetle can include maintaining uneven-aged stands. Since pine beetles prefer older, dense stands, selective thinning and propagation of younger trees can increase the resiliency of forests to beetle attacks (Leatherman et al., 2007).

MOUNTAIN ZONE

The mountain zone in Utah generally occurs between 6,900 and 9,200 feet in elevation. The mountain zone occupies about 3,561,884 acres, or 6.6 percent of the state. The zone is widely distributed where moderately high mountains or plateaus rise up. The climate at such elevations involves cool, humid winters and warm, dry summers. The reference evapotranspiration exceeds precipitation for approximately 5½ months (Figure 7.16). Mean annual precipitation varies between 10.4 inches in the winter months (December to March) and 5 inches during the summer. Total mean annual precipitation in this zone is 26.3 inches. Mean annual temperatures vary between 23.4 degrees Fahrenheit during the winter months and 57.3 degrees Fahrenheit during the summer with wide variations. The growing season ranges from mid-May to the first week of September (Figure 7.17). At times, the growing season can be longer than either areas above or below this zone because drainage of cold air to valleys below often pushes up warmer air into this "thermal belt" during periods of wind-free, high air pressure.

The topography within this zone varies from steep, rocky, lower mountain slopes or hills to plateaus or gently sloping meadowlands. The soils range from Entisols and Inceptisols to Mollisols, respectively.

The vegetation within this zone varies from big sagebrush steppe to conifer and aspen forests, and pinyon-juniper woodlands to tall shrublands. The tall shrublands are found more abundantly in the upland zone and will be discussed there. The variety of current vegetation is reflected in Table 7.5. In the discussion of the mountain zone, the mountain big sagebrush and aspen communities are considered.

Approximately 87 percent of the mountain zone is found within the Wasatch and Uinta Mountains MLRA, with 8 percent occurring in the Great Salt Lake Area MLRA. Other MLRAs that contain this zone include the Owyhee High Plateaus, Southern Rocky Mountains, and Southern Nevada Basin and Range.

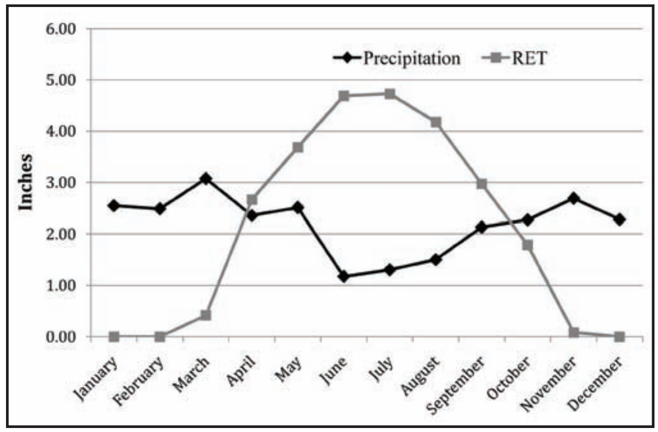


Figure 7.16. Monthly distribution of precipitation within the mountain zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

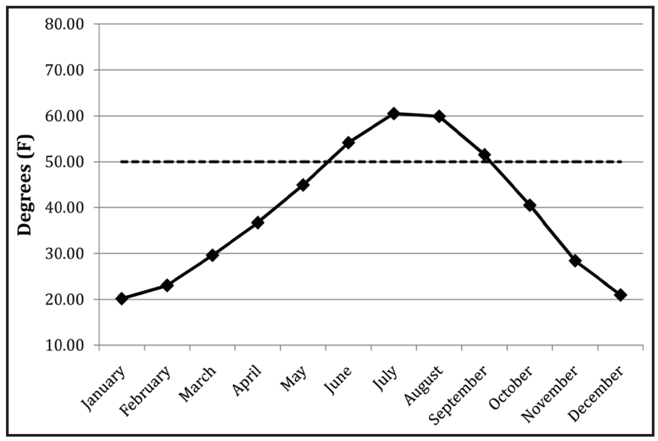
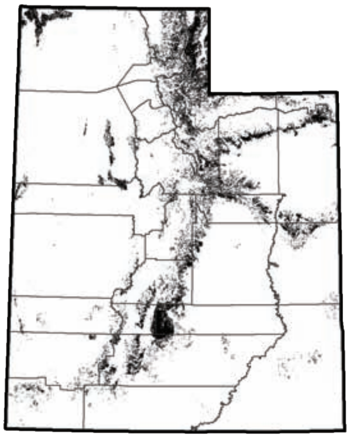


Figure 7.17. Average monthly temperatures within the mountain zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.5. Distribution of generalized SWReGAP land cover types across the mountain zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Big Sagebrush	933,994	26
Aspen	881,192	25
Oak Brush	423,798	13
Spruce-Fir	314,603	9
Mixed Conifer	245,362	7
Lodgepole Pine	156,360	4
Bigtooth Maple	105,781	3
Pinyon-Juniper	76,317	2
Miscellaneous	369,020	11
TOTAL	3,561,123	100

MOUNTAIN BIG SAGEBRUSH COMMUNITIES

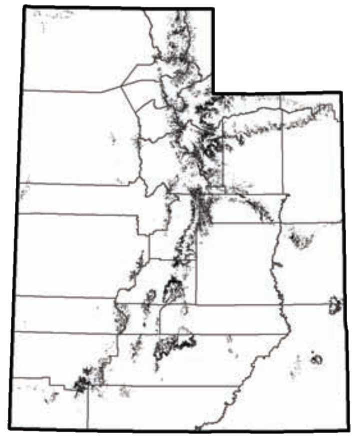


Mountain big sagebrush dominated communities occur across 26 percent of the mountain life zone. Big sagebrush communities occur across the mountain, upland, and semidesert zones. Each zone supports a different subspecies of big sagebrush. The three most common subspecies of big sagebrush (*Artemisia tridentata*) are basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), which is predominantly found in the lower basins, Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), which is found on higher elevation foothills, and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), which occurs at higher elevations in the mountain zone (Photograph 8). Mountain big sagebrush communities are not a significant source of forage for domestic grazers. Use by cattle and sheep is variable. Grazing by domestic livestock relies on associated understory plants.

Mountain big sagebrush prefers moderately deep (approximately 30 inches), well-drained, gravelly loam soils and is typically associated with dry-to-moist mountain meadows that can support a significant amount of forage production in the form of grasses and forbs. These communities can also be found on flat ridge tops and mountain slopes. Understory production of perennial forbs and grasses varies depending on site quality. Other shrubs typically associated with mountain big sagebrush communities include antelope bitterbrush (*Purshia tridentata*), snowberry (*Symphoricarpos* spp.), serviceberry (*Amelanchier* spp.), wild crab apple (*Peraphyllum ramosissimum*), and wax currant (*Ribes cereum*). The associated herbaceous cover can exceed 25 percent of the total ground cover. Graminoids include Idaho fescue (*Festuca idahoensis*), needle and thread (*Hesperostipa comata*), muttongrass (*Poa fendleriana*), slender wheatgrass (*Elymus trachycaulus*), sandberg bluegrass (*Poa secunda*), spike fescue (*Leucopoa kingii*), tufted hairgrass (*Deschampsia caespitosa*), pinegrass (*Calamagrostis rubescens*), and bluebunch wheatgrass (*Pseudoroegneria spicata*).

As with most habitat types in the upper elevation life zones, mountain big sagebrush communities host a number of wildlife species from large ungulates, such as elk and mule deer that browse on the more fleshy parts of this variety of big sagebrush, to small, ground-dwelling mammals. These communities also support a wide range of predators from raptors to mountain lions, foxes, weasels, and snakes.

ASPEN COMMUNITIES



Aspen communities are considered a seral type, giving way to coniferous communities, including Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), subalpine fir (*Abies lasiocarpa*), Englemann spruce (*Picea engelmannii*), blue spruce (*Picea pungens*), lodgepole pine (*Pinus contorta*), limber pine (*Pinus flexilis*), and/or ponderosa pine (*Pinus ponderosa*), depending on location and environmental conditions (Photograph 9). While usually seral, aspen can occur as a relatively pure (pseudo-climax) community depending on seed availability of conifers and stability of the soils. This is particularly the case where the churning clays of Vertisols predominate.

Aspen stands occur across the upland, mountain, and high mountain life zones, but have a modal occurrence in the mountain zone (Figure 7.18). These plant communities are highly productive and are known for their significant understory production that can range from 180 pounds per acre to more than 1,300 pounds per acre, depending on site conditions for pure aspen stands. As conifers invade, this production can drop to less than 100 pounds per acre when conifer canopy cover reaches 50 percent and approaches zero pounds per acre as conifers reach 100 percent canopy cover (Stam et al., 2008).

Recent studies have shown that this community type has shown a marked decrease in its occurrence in Utah and across the Intermountain West (Bartos, 2008). There is no single reason for aspen decline, but it is generally attributed to fire suppression activities as well as overgrazing by wild and domestic animals. Aspen suckers are readily eaten by elk, which occurs throughout the aspen range. Aspen regeneration is predominantly dependent on sprouting from roots rather than from seed. Due to its dependence on root sprouting, aspen communities require a regular disturbance regime to retain dominance on the landscape and to maintain stand health. The absence of disturbance, which includes fire or mechanical removal, allows shade-tolerant conifers to invade that eventually eliminate the more shade-intolerant aspen.

Aspen communities support a large number of birds and mammals, including most large raptors and many songbirds. Large mammals that rely on aspen communities for habitat include elk, mule deer, moose, black bear, mountain lion, and bobcats. Additionally, aspen host a number of squirrels, gophers, mice, and rabbits, as well as medium-sized mammals, such as badgers, porcupines, skunks, and foxes.

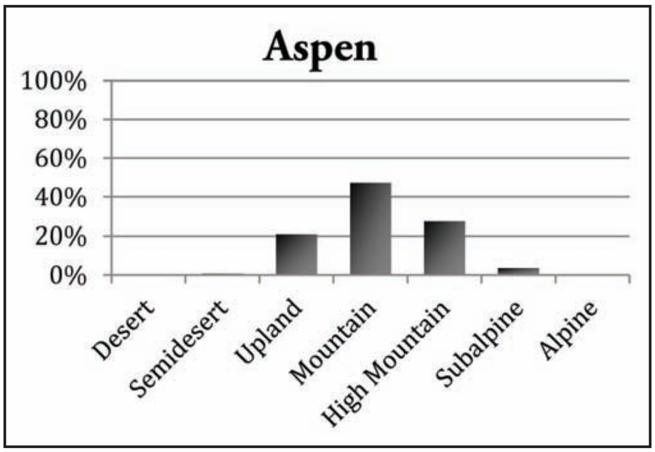


Figure 7.18. Distribution of aspen communities across life zones.

UPLAND ZONE

The upland zone occurs below the mountain zone at approximately 5,800 to 8,300 feet in elevation. This zone occupies 9,271,582 acres, or 17 percent of the state. This zone is predominantly defined by foothills around the higher mountain ranges, as well as tops of lower mountains and escarpments. The upland zone is associated with the majority of the urban and rural development. The climate of the upland zone is warm during summers, cool during winters, and drier than the adjacent higher elevations. The reference evapotranspiration exceeds precipitation for approximately 6½ months (Figure 7.19). Mean annual precipitation ranges from 7.1 inches during winter months and 4.3 inches during summer for a total mean annual precipitation of 19.6 inches. Mean annual temperatures vary between 26.7 degrees Fahrenheit during the winter months and 61.8 degrees Fahrenheit during the summer. The growing season ranges from the beginning of May to mid-September (Figure 7.20).

The topography of the upland zone is generally gentler than the zones above, although some steep, rocky areas are to be expected locally. The soils range from shallow Entisols on steeper slopes to Mollisols on gentler terrain and Aridisols in the lower portions of the life zone.

The vegetation of the upland zone is dominated by three major kinds of widespread taxa, including sagebrushes, pinyon and juniper trees, and oak and mountain brush (Table 7.6). Since pinyon and juniper communities are more prevalent in the semidesert life zone, they will be discussed in that section. A smaller component of the upland zone (4 percent) is the ponderosa pine ecosystem. Although it is a small component, it has the majority of its distribution in the upland zone.

This life zone is spread across multiple NRCS MLRAs, but is dominant in the Wasatch and Uinta Mountains (52 percent) and the Great Salt Lake Area (25 percent). Smaller occurrences of this zone can be found in the Southern Rocky Mountains (6 percent), Central Desertic Basins, Mountains, and Plateaus (5 percent), the Owyhee High Plateaus (3 percent), and Arizona and New Mexico Mountains (2 percent). All other MLRAs have trace amounts of the upland zone except for the San Juan River Valley, Mesas, and Plateaus MRLA that has no occurrence within this zone.

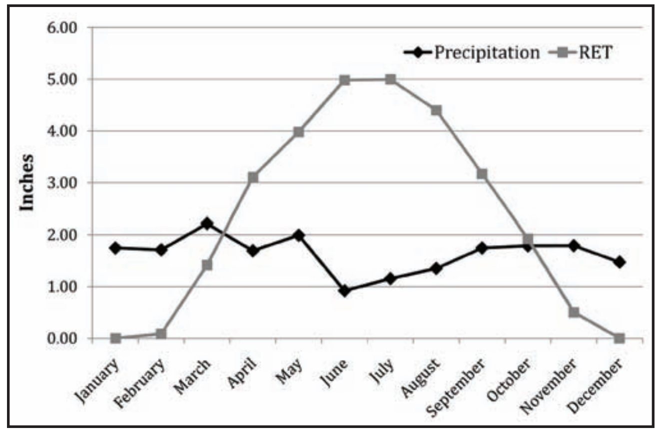


Figure 7.19. Monthly distribution of precipitation within the upland zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

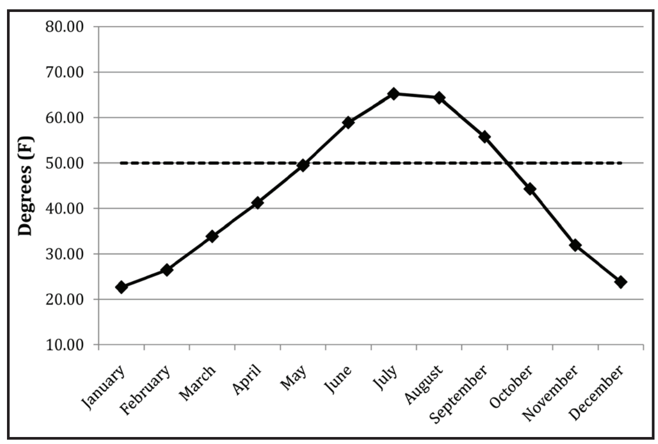
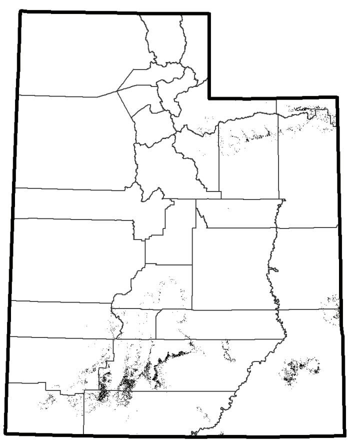


Figure 7.20. Average monthly temperatures within the upland zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.6. Distribution of generalized SWReGAP land cover types across the upland zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Big Sagebrush	2,638,458	28
Pinyon-Juniper	2,492,596	27
Oak Brush	1,070,979	11
Agriculture	556,133	6
Aspen	393,170	4
Mixed Conifer	350,378	4
Ponderosa Pine	332,481	4
Developed	269,176	3
Cliff and Canyon	162,820	2
Spruce-Fir	141,533	2
Miscellaneous	848,260	9
TOTAL	9,255,984	100

PONDEROSA PINE COMMUNITIES



Ponderosa pine communities are most common in southern Utah along the southern flank of the Markagunt and Aquarius Plateaus. They are also found in the Colorado Plateau region in the Henry, Abajo, and La Sal mountains. The only occurrence of this type in northern Utah is along the south slope of the Uinta Mountains stretching to the east and north into Daggett County. These communities occur at the lower extent of coniferous forests forming an ecotone between the higher elevation, more mesic forests and the lower elevation, pinyon-juniper and shrubland types (Photographs 10 and 11).

Common trees include ponderosa pine (*Pinus ponderosa*) as the dominant conifer. Douglas-fir (*Pseudotsuga menziesii*), two-needle pinyon (*Pinus edulis*), and junipers may also be present. The understory is usually shrubby and somewhat productive, with big sagebrush (*Artemisia tridentata*), greenleaf manzanita (*Arctostaphylos patula*), kinnikinnick (*Arctostaphylos uva-ursi*), alderleaf mountain mahogany (*Cercocarpus montanus*), Stansbury cliffrose (*Purshia stansburiana*), antelope bitterbrush (*Purshia tridentata*), Gambel oak (*Quercus gambelii*), mountain snowberry (*Symphoricarpos oreophilus*), chokecherry (*Prunus virginiana*), Saskatoon serviceberry (*Amelanchier alnifolia*), and wild roses (*Rosa* spp.) commonly found. Bluebunch wheatgrass (*Pseudoroegneria spicata*), needle and thread (*Hesperostipa* spp.), needlegrass (*Achnatherum* spp.), fescues (*Festuca* spp.), muhlys (*Muhlenbergia* spp.), and gramas (*Bouteloua* spp.) are some of the common grasses.

This type covers nearly 500,000 acres and occurs most dominantly in the upland zone (67 percent) with some occurrence in the semidesert zone (26 percent) (Figure 7.21). The plant communities in ponderosa pine woodlands vary from open meadow in valleys with seasonally high water tables and cold air drainage to open forest on drier, steeper sites with shallow soils. Even on the better sites, the trees are not dense and grow in open, park-like stands, especially if fire has been allowed to periodically carry through them (McAvoy et al., 2004).

This community is adapted to a high-frequency, low-intensity fire environment that maintains its open condition. Ponderosa pine have evolved with fire, and consequently, they have developed a thick bark to protect themselves from fire damage. It was originally thought that an average fire return interval of 4 to 8 years was common in these environments prior to European settlement. However, recent research by Sherriff and Veblen (2007) shows that 80 percent of ponderosa pine woodlands in Colorado had a mean fire return interval of greater than 30 years prior to 1915. Madany and West (1983) showed that surface fires once every 50 years are required to keep the less fire-tolerant trees (true firs, Douglas-fir, Rocky Mountain juniper) at low densities if livestock grazing is absent.

Ponderosa pine communities provide seasonal habitat for a variety of vertebrates. The most permanent large mammals are mule deer and elk. Cougar and coyotes are important predators. The Kaibab squirrel is a unique game animal. Red squirrels and porcupines harvest cones and cambial tissues of the pines, respectively.

Prominent birds of the ponderosa pine ecosystem are the white-breasted nuthatch, Steller's jay, common flicker, and Merriam's turkey. Among invertebrates, one insect is particularly notable, the western pine beetle (*Dendroctnus ponderosae*). This insect periodically infests stands of ponderosa pine and can cause considerable mortality.

Europeans began selectively harvesting timber and grazing livestock in the ponderosa pine type in the 1870s. There were abundant herbaceous species under the widely scattered trees (Madany and West, 1983). Unrestricted livestock numbers, however, quickly reduced the desirable forages. Without the fine herbaceous fuels, light ground fires can not spread through these forests to thin and prune the pines and keep out invading conifers. There was also conscious control of fire that exacerbated successional changes. It was not until about the 1950s that most managers began to realize that fire had a role in maintaining more desirable and sustainable conditions. By 1980, a great portion of these forests were not capable of supporting much livestock use.

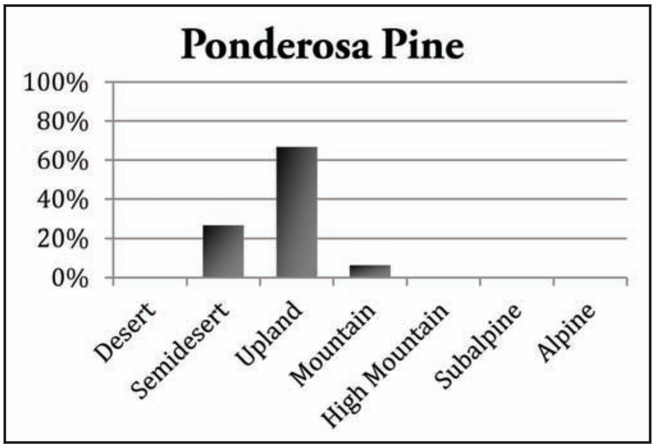
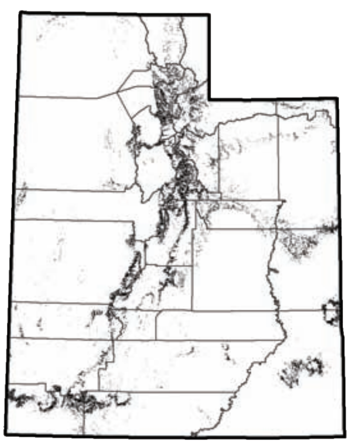


Figure 7.21. Distribution of ponderosa pine communities across life zones.

OAK AND MOUNTAIN BRUSH COMMUNITIES



Oak and mountain brush communities are defined by tall, shrub-dominated vegetation. They typically occur at elevations between 5,000 and 8,000 feet in Utah and usually form a transition zone between the coniferous forests above and the pinyon-juniper woodlands below. Oak and mountain brush communities are best developed along the flanks of the Wasatch Mountains and Wasatch Plateau in the northern half of the state (Photograph 12). Outliers occur in the Book Cliffs, the Pine Valley, La Sal and Abajo Mountains, and on other higher prominences in the Colorado Plateau. The type is largely limited to small patches on the mountains within the Great Basin. The Southwest Regional Gap Analysis project estimated that there were over 1.07 million acres of oak brush and approximately 74,000 acres of the mountain browse type, located predominantly in the upland type of Utah (Figure 7.22). Mountain brush or mountain browse communities are sometimes known as Wasatch chaparral or mountain mahogany-oak scrub.

Because the great majority of lands dominated by tall shrubs are steep and dissected, their major values are as watersheds and wildlife habitat. Mountain brush areas on gentler topography and deeper soils get some spring and fall use by livestock. Sites close to roads where shrubs are of sufficient size for firewood are becoming more popular. Since these types are found along foothills, a majority is in private ownership. The United States Forest Service manages the remainder.

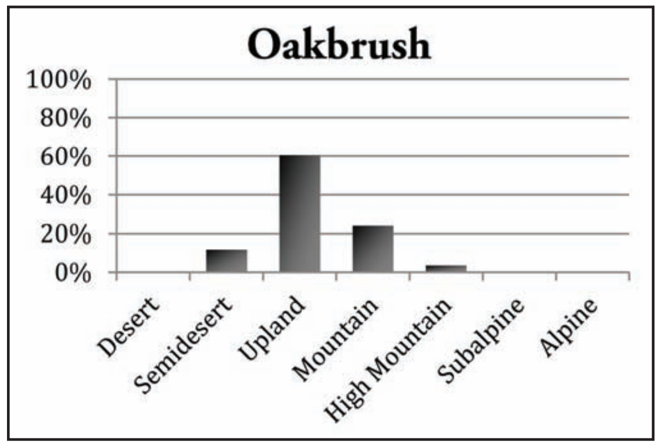


Figure 7.22. Distribution of oakbrush communities across life zones.

Oak and mountain brush communities frequently form a thermal belt in winter and spring because cold air drains to the valley bottoms during periods of high atmospheric pressure. Thus, a longer growth period is produced than would otherwise be expected at these elevations. When combined with a total average annual precipitation of 14 to 25 inches, Mollisols can form on sites of moderate slope. Soil pH tends to be acidic where these shrubs dominate. The deciduous species cycle more nutrients than evergreen species, and thus, the soils are often rich in nutrients.

The flora of mountain brush zones is moderately rich in plant species in a variety of life forms. Major tall shrubs are curlleaf mountain mahogany (*Cercocarpus ledifolius*), true mountain mahogany (*Cercocarpus montanus*), Gambel oak (*Quercus gambelii*), scrub oak (*Quercus turbinella*), big tooth maple (*Acer grandidentatum*), skunkbush sumac (*Rhus trilobata*), and cliff rose (*Cowania mexicana*). Common, shorter-statured shrubs are serviceberry (*Amelanchier alnifolia*), bitterbrush (*Purshia tridentata*), Apache plume (*Fallugia paradoxa*), snowberries (*Symphoricarpos* spp.), deerbrushes (*Ceanothus* spp.), and manzanitas (*Arctostaphylos* spp.). The oaks seem to thrive on calcareous soils of clayish texture. The mountain mahoganies, particularly the evergreen species, occur on steeper sites with shallower soils and typically have less understory vegetation.

There are abundant grasses and forbs in the interspaces between shrub clumps (mottes). Major grasses are needlegrasses (*Stipa* spp.), bluegrasses (*Poa* spp.), junegrass (*Koeleria macrantha*), wheatgrasses (*Agropyron* spp.), and perennial bromes (*Bromus* spp). Major forbs are yarrow (*Achillea millefolium*), fleabanes (*Erigeron* spp.), vetches (*Vicia* spp.), showy golden eye (*Heliomeris multiflora*), and hairy false golden aster (*Heterotheca villosa*).

Herbage and browse production vary with site favorability and condition class, but in general are much higher than for the forest types previously discussed. An additional food value is derived from the oak mast (acorns). Very little community classification has been done in this vegetation type in Utah (Harper et al., 1985), but such study is needed to aid more sophisticated research and management. Clary and Tiedemann (1985) pointed out that the standing crop biomass of oakbrush approximates the lower range of coniferous stands in the interior West. The extraordinarily high caloric values of the wood also confer clear fuel wood values.

Oak and mountain browse communities are very important for deer and elk, particularly in winters with low-to-moderate snow packs. A wide range of birds and small mammals also use these communities (Hayward, 1948). Valley quail, Merriam's turkey, band-tailed pigeon, and blue and ruffed grouse are the main game birds found here. Little is known of the insects and pathogens in this ecosystem, but none seem to drastically reduce the dominant shrubs.

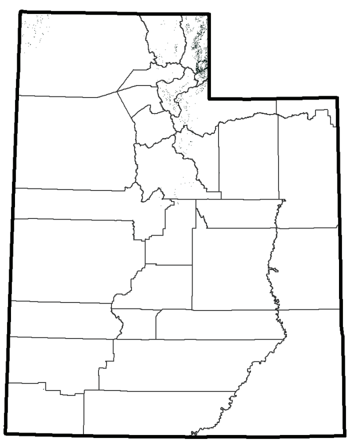
There is abundant evidence that oaks were shorter in stature and occupied a smaller fraction of the land before livestock grazing and fire control took place (Harper et al., 1985; Madany and West, 1984). Livestock grazing reduced herbaceous production resulting in less fine fuels to carry fire. The high tannin load in oakbrush leaves can cause cattle poisoning, but have been grazed by goats supported by dietary supplements. Selective avoidance of these shrubs only adds to the dominance of these woody species. Nearly all of the major woody species can spread by sprouting. Mottes (clones) of oak have spread into what were formerly interspaces dominated by herbaceous species (Harper et al., 1985). Part of the mountain browse type is not climax, but is sub-seral to white fir, Rocky Mountain juniper, or maple (Harper et al., 1985). This trend is probably due to lengthening of the fire return interval through livestock grazing and direct fire prevention. The vigorous resprouting of oak and mountain mahoganies on most sites following fires assures their continued dominance, whereas the other species succumb to burning.

The amount of woody vegetation is related to water yield. Because Gambel oak has been shown to deplete about 3 inches more water from the soil than perennial range grasses on the same site (Tew, 1967; Tew, 1969), there has likely been a decline in water yield as woody plants have expanded. This has not been total loss, however, because the woody plants send their roots deep into the cracks between the rocks to better stabilize the soil. The problems will come from the greater chance of catastrophic fire, particularly in years when late frosts kill oakbrush leaves. The high fraction of private land means that more of this type has been put into urban and rural development. Consequently, fire prevention may continue to be encouraged and use by wildlife may be discouraged.

Aboriginals apparently used oak and mountain brush communities only as hunting and gathering grounds. Oak acorns were used as a food source. Major changes followed the introduction of livestock, beginning about 1850. Early settlers recount how easy it was to see livestock moving through the generally low and scattered brush. Unrestricted grazing and direct fire control eventually led to higher and thicker growth of the brush. During this transition, the land was partially bared, leading to accelerated erosion. The over harvest of deer and elk led to reduced pressure on the browse portions. The tightening of wildland use with the creation of forest reserves and water conservancy districts led to reduced livestock use on most of this land and its removal from the steeper areas of municipal watersheds. Herbaceous understories recover very slowly after removal or reduction of livestock. Therefore, beginning in the late 1940s, private landholders and the Utah Division of Wildlife Resources developed ways of reducing brush on the gentler sites with deeper soils. Mechanical, herbicidal, or prescribed burning treatments are generally short-lived, and repeated brush control is usually necessary. Although Bowns (1985) reported an instance where shrub control and seedbed preparation were not necessary for establishment of a good stand of grass, the usual approach has been to seed after shrub control and site preparation. A wide variety of desirable grasses, forbs, and shrubs can be used in the type (Stevens and Davis, 1985).

Conflicts between livestock and big game animals and between recreation and urban development will probably continue to intensify. The large fraction of the type in private ownership makes changes in land use more rapid. The relative ease of converting overgrown oak with poor understories to more productive pastures will make it possible to greatly increase both domestic and wild red meat production on these ranges, when and if greater demand should return. The possibilities of more systematic harvests of oak for firewood should be explored. The additional returns from the land (Wagstaff, 1984), plus enhanced water yields, may accelerate a trend toward more sophisticated management of this range type.

SAGEBRUSH STEPPE COMMUNITIES



Sagebrush steppe communities occur where there is roughly equivalent dominance of sagebrush and herbaceous species, provided that the land is free from human disturbance. There is a gradient of increasing occurrence of sagebrush dominance from northern to southern latitudes and from high elevations in the foothills to valley bottoms. The dividing lines between the sagebrush steppe and sagebrush shrublands are arbitrary. These two types are thus closely related, and it is more the degree to which phenomena are expressed than the fundamental nature of the phenomena that is important. The sagebrush steppe is predominantly located in the northern part of the state and is most dominant in Rich and Box Elder counties (Photograph 13).

The primary use of the sagebrush steppe communities has been grazing by domestic animals and habitat for wildlife. Some occurrences of this type on gentler slopes with deeper soils and appropriate climate have been converted to farmland. Shrub steppe provides critical spring-fall range for livestock grazing operations, being located between the summer mountain ranges and winter desert ranges.

Sagebrush steppe communities generally occurs on foothills or on the upper parts of valleys where total annual precipitation averages 9 to 12 inches. About half of this precipitation occurs between December and March. The frost-free period is 80 to 120 days. Soils vary from Mollisols to Aridisols, depending on meso-relief and the amount of herbaceous vegetation needed to supplement organic matter in the soil.

The vertical and horizontal structure of vegetation is remarkably uniform unless fires have been periodic and patchy. The shrub layer reaches 3 to 6 feet high and may have cover varying from 10 to 80 percent, depending on site and successional status. The grass and forb layer reaches 18 to 24 inches during the growing season. Herbaceous cover may vary between 0 and 100 percent, depending on site and successional status.

Floristic diversity in this vegetation type is moderate. An exception is the sagebrush/grass type occurring in higher elevation habitats with 12 to 20 inches of precipitation where the floristic diversity is higher. Subdivision of this vegetation type requires identification of different species and even sub-species of big sagebrush. This is because these taxa prefer different kinds of sites (West, 1983a). Bluebunch wheatgrass (*Pseudoroegneria spicata*) is probably the most widespread and important grass associate. Thurber's needlegrass (*Achnatherum thurberianum*) and Indian ricegrass (*Achnatherum hymenoides*) are also important grasses.

Total aboveground phytomass can vary between 1 and 5 tons per acre (West, 1983a). Because sagebrush develops long-lived, woody tissues and over-wintering leaves, as little as 15 percent of the phytomass may be due to current annual growth if the sagebrush is particularly old or dense. Sagebrush may contribute up to 70 percent of the total aboveground phytomass, even on sites where livestock grazing has been light or absent. Brush dominance is even greater where livestock grazing has reduced the perennial herbaceous species.

These rangelands are important winter range for mule deer and elk. The smaller native animals are a mix of grassland and desert species. An important game bird here is the sage grouse. Their populations have been lowered by the loss of herbaceous species, increase in height and densities of sagebrush, as well as other factors. Sage grouse chicks need forb buds and insects found most abundantly along riparian inclusions. At breeding time, adults need open "booming" grounds.

There are occasional outbreaks of insects that greatly influence this vegetation. The sagebrush web worm (*Aroga websteri*) can defoliate sagebrush. Grasshoppers and Mormon crickets occasionally damage the herbaceous vegetation. Relatively little is known of the other insect fauna and their influences (West, 1983a). Snow mold also greatly reduces sagebrush some years (Allen et al., 1987).

The major ecological interactions center on the balance of brush and herbaceous species. The shrubs have the physiological and competitive advantages in the absence of fire or insect outbreaks. The pristine ecosystem was apparently only weakly stable. The perturbations triggered by the introductions of livestock and European weeds are essentially irreversible without considerable effort. An increase in big sagebrush can cause a drying out of the soils because they carry on transpiration year-round, leading to reductions in water discharge. If cheatgrass becomes dominant, the frequency and seasonality of fire changes, reducing the ability of big sagebrush to re-establish itself.

Sagebrush steppe communities were greatly affected by livestock owned by European colonists from 1850 to 1870. Mere reduction of livestock numbers and control of season of use does little to repair damage to forage production, especially in the face of continuing waves of weed introductions. Rest rotation grazing in only fall or winter may allow more regeneration of perennial herbaceous species. Due to the overgrazing of the herbaceous species and the subsequent increase in sagebrush cover during the mid 1900s, a significant amount of sagebrush control in the form of tillage and the application of herbicide and fire was applied in an attempt to restore the herbaceous component. With the introduction of invasive species, such as cheatgrass that can quickly become dominant in these environments and permanently remove sagebrush, more effort has been focused on the retention and expansion of sagebrush-steppe in order to restore proper ecosystem functions. This effort is largely due to the loss of sage grouse habitat. Sage grouse are currently being considered as a possible threatened or endangered species. Restoring proper functioning conditions to sagebrush-steppe environments can also improve large ungulate habitat, livestock production, and water discharge.

The lands with steeper slopes and shallower soils will remain as rangelands. Better understanding of how these ecosystems function, and improved means to enhance production through prescribed burning, grazing management, herbicides, and seeding of exotic species, provide opportunities for increased production.

SEMIDESERT ZONE

The semidesert life zone occupies approximately 60 percent of the state and occurs throughout the Great Basin, Colorado Plateau, and Uinta Basin regions. The zone ranges in elevation from 4,500 feet to 6,400 feet ASL. Semidesert environments are characterized by a mean annual precipitation between 8 and 12 inches. The annual reference evapotranspiration is higher than precipitation for 10 months of the year yielding an annual water deficit (Figure 7.23). Precipitation during the winter is generally higher than during other seasons (approximately 4.1 inches). The Great Basin component of this life zone has a drier summer than the Colorado Plateau due to monsoonal storms that pass through the area in mid-to-late summer. Mean annual temperatures range from 32 degrees Fahrenheit in the winter to 69 degrees Fahrenheit in the summer. The growing season generally starts in early- to mid-April and runs through the end of September (Figure 7.24).

Vegetation consists of shrub-dominated landscapes with a small component of herbs and a lower component of succulents. Because this life zone occupies such a large portion of the state, most of Utah rangeland occurs here. Fifty-five percent of the developed land and 74 percent of irrigated agriculture occurs within this zone. Natural landscapes predominantly include pinyon-juniper, salt desert shrub, and big sagebrush shrublands (Table 7.7). Smaller, but relatively unique vegetation types consist of greasewood, mat saltbush, and creosote-white bursage communities. Invasive species are also a large component of this landscape, with the primary exotic being cheatgrass (*Bromus tectorum*). The topography is relatively flat compared to the more mountainous portions of Utah, but it is dissected by canyons, cliffs, and scarps, especially within the Colorado Plateau region. Soils in the semidesert life zone consist of Aridisols and Entisols, with a smaller component of Mollisols in the upper elevations where more forage production occurs. The majority of this zone falls within the Great Salt Lake Area (48 percent), Colorado and Green River Plateaus (19 percent), and the Central Desertic Basins, Mountains, and Plateaus (17 percent) MLRAs. Smaller components are spread across the remaining MLRAs that occur in Utah.

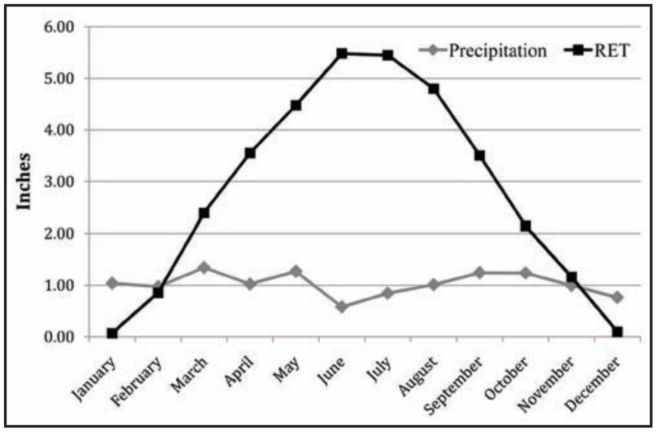


Figure 7.23. Monthly distribution of precipitation within the semidesert zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

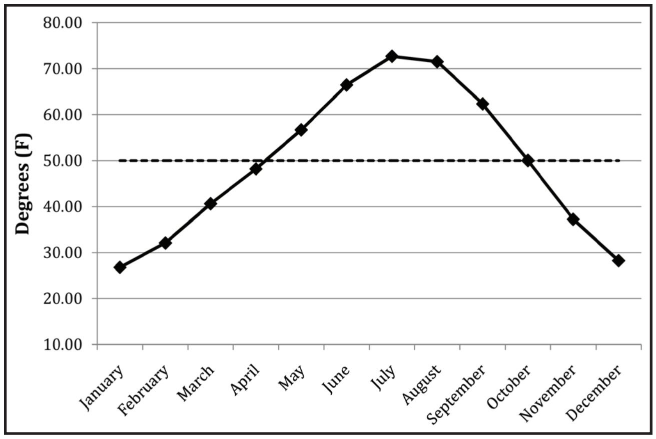
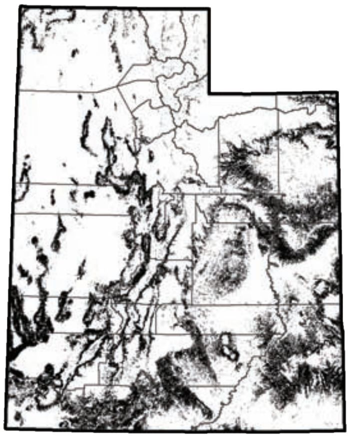


Figure 7.24. Average monthly temperatures within the semidesert zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

Table 7.7. Distribution of generalized SWReGAP land cover types across the semidesert zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Pinyon-Juniper	7,864,329	24
Salt Desert Shrub	5,770,808	18
Big Sagebrush	4,559,135	14
Tableland	2,002,820	6
Shrub Steppe	1,880,287	6
Playa	1,837,523	6
Agriculture	1,683,680	5
Open Water	1,346,235	4
Low Sagebrush	1,219,863	4
Invasive	1,021,793	3
Blackbrush-Mormon Tea	832,000	3
Miscellaneous	2,603,977	8
TOTAL	32,622,450	100

PINYON-JUNIPER COMMUNITIES



A large fraction (24 percent) of the semidesert zone is dominated by pinyon-juniper woodlands. Seventy-five percent of all pinyon-juniper communities in the state fall within the semidesert zone (Figure 7.25). In the Great Basin, Utah juniper (*Juniperus osteosperma*) occurs either alone or together with singleneedle pinyon (*Pinus monophylla*). On the Colorado Plateau, Utah juniper and true pinyon (*Pinus edulis*) dominate. One seed juniper (*Juniperus monosperma*) occurs in the extreme south. Pure juniper stands are usually found at lower elevations and, thus, on drier sites in both regions (Photographs 14 and 15).

There is a considerable difference between what existed before European colonization and what exists now. This is because trees have increased in density, especially within the mountain zone, or have invaded adjacent zones. This is thought to be due to a combination of excessive utilization of understory by livestock and big game, reduced competition from diminished understory, subsequent reduction in chance of burning, conscious fire control, climatic trends favorable to tree establishment, and dispersal of tree seeds by livestock, birds, and small mammals (West, 1999). Because all of these influences act concomitantly, it is impossible to separate their individual effects except under most unusual circumstances.

Pinyon-juniper woodlands now generally have a remarkably poor flora, especially considering the huge area they occupy (West et al., 1998). Additionally, most stands have only a shrub species or two, chiefly big sagebrush, and about a dozen species of grasses and forbs. This is because there is a negatively exponential decline in forage production with successional thickening and enlargement of the trees (Tausch et al., 1981).

The uppermost part of the woodland structure is characterized by scattered trees rarely amounting to more than 50 percent canopy coverage. Aboveground phytomass, largely due to trees, can reach 125 tons per acre. This translates to about 40 cords per acre on the very best sites. Accumulation rates for wood are very poorly known. Pinyon nuts (seeds) are known to be produced at the rate of up to 165 pounds per acre (Spencer, 1984). Such production is very temporally and spatially erratic, although there is some potential for increasing nut production with management.

Shrubs are scattered in the interspaces between the trees, if tree density is not too great. However, the influence of the trees extends over an area two to three times wider than their crowns through a widespread fibrous root system that heavily competes with understory species in the interspaces. A few herbs are successful under the tree canopies. Soil microphytic crusts (mosses, lichens, algae, fungi, and liverworts) often cover the interspaces where tree litter or vascular understory plants are sparse or lacking on sites with fine-textured soils.

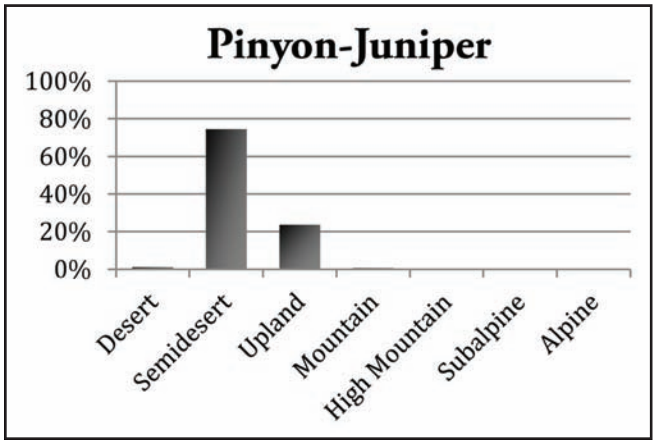


Figure 7.25. Distribution of pinyon-juniper communities across life zones.

Pinyon-juniper woodlands are seasonal habitats for deer and elk and many songbirds. Notable year-round residents are the pinyon jay and pinyon mouse. No insects have evolved to utilize the vast store of plant tissues in any major way. The high loads of secondary chemicals in pinyon and juniper tissues apparently protect them from significant herbivory. This, along with high ecophysiological efficiency, allows the trees to greatly expand at the expense of understory when fire is removed as a regulatory feature (West et al., 1979; West, 1999).

Periodic fires, about once every 50 years on a given piece of ground (Wright et al., 1979), apparently created open woodlands or savannas in the pristine vegetation. This was probably more the case in the Great Basin than the Colorado Plateau because broken topography in the latter region would have kept fire sizes smaller (West and Van Pelt, 1987). In both regions, extremely old trees are largely limited to steep, rocky, fireproof sites. As trees thickened on most portions of the landscape during the twentieth century, animal dispersal of seed probably became more important in augmenting tree dominance. Birds, such as pinyon jays and Clark's nutcrackers, collect and cache pinyon seeds. Townsend solitares, robins, and cattle consume juniper fruits and deposit the seeds in their defecations. Unlike other coniferous tree dominated ecosystems in the Intermountain West, no insect, pathogen, or parasite buildups that noticeably reduce tree dominance have been observed. Extended drought in the 1990s did, however, result in expansive die off, particularly in southern Utah.

Humans affected pinyon-juniper woodlands at least 800 to 1,000 years ago. In fact, some (Samuels and Betancourt, 1982) believe that utilization may have exceeded growth increments of the trees when the ancestral Puebloans were occupying portions of the Four Corners Region. Although information on prehistoric and historic land use is tenuous, it should not be assumed that all of these woodlands were pristine when Europeans arrived. It is interesting to note that some of the earliest European explorers of this region would have probably died had the Indians not shown them how to gather and eat pinyon seeds.

Livestock grazing, fire control, and wood harvest by European settlers have had profound impacts on these woodlands. Charcoal makers harvested the trees around mining districts of the Great Basin in the 1870s, but there was simultaneous intense, unrestricted livestock grazing. Loss of herbaceous understory has apparently led to accelerated soil erosion during the past century (Carrara and Carroll, 1979). Because the majority of these woodlands are heavily invaded by trees and possess little understory, this is of no small concern. The problem is that the roots of pinyon and juniper grow far beyond their crowns. When the understory dies through competitive displacement, bare soil is exposed.

It has been only in the past 20 years that these successional processes have been understood and some reversals have been attempted. A logical action would be to use prescribed burning. Unfortunately, there is now so little fine fuel in the understory that this is not possible on the more productive sites. Crown fires can only take place under high winds in the dry summer. These fires are often so hot that everything living is burned. Soil seed reserves of desirable native plants are also usually minimal under such stands, resulting in slow natural recovery. Second generation herbicides can also be used to kill pinyon and juniper (Clary et al., 1985). It would, however, be desirable to utilize the wood, but no one has yet developed an economical way to do so over large acreages distant from population centers.

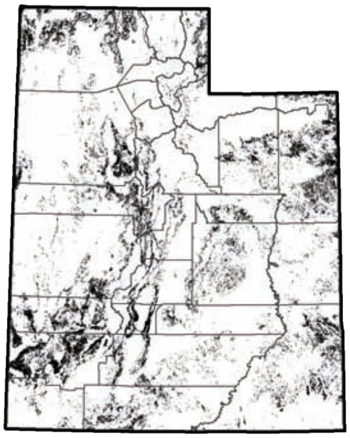
During post-World War II years, range and wildlife managers used cables and chains drawn between large crawler tractors to pull over the trees. Grasses were seeded either between chaining or after ricking and burning of debris so that seed drills could be used. The increase in forage production was 20 to 30 fold (West, 1984a). The longevity of these treatments was primarily related to thoroughness of treatment, but also to other pre-and post-treatment influences (West, 1984b). Planting a variety of browse and forbs and designing the chaining to provide nearby escape cover enhanced big game utilization. Whether these treatments have slowed erosion and what effects they have had on other species of wildlife and on archeological evidence have been hotly debated. Environmentalist pressure largely stopped such actions before the high costs of energy and low meat prices put a moratorium on such conversions in the 1970s and 1980s. As a result, these communities continue to thicken and expand of the trees (West, 1999), with further reduction of understory vegetation and accelerated soil erosion. Additionally, chainings are also being reinvaded by trees and brush.

It seems logical to place first priority on recapturing the forage production on previously chained areas. These are generally the most productive sites and they already have fences and water developments. Scenic, archeological, and other natural features were disturbed by the first treatment. Prescribed burning or second-generation herbicides could now be used to reduce the undesirable woody species (West and Van Pelt, 1987). Genetically improved forage plants could be replanted if inadequate residual stands of forage plants remain.

Recently, the tree masticator, colloquially known as the "bull-hog," followed by seeding, if necessary, has been successfully used to quickly change woodland to savanna in selected locations, especially where fire threatens high-value real estate. Unfortunately, this process is too expensive to employ over large areas.

Thus, little hope is seen in the near future for reversing the successional changes in the much larger area that has not been mechanically treated. Until some means of generating additional revenue from tree harvest is developed, more active management is unlikely. Managers must show that harvest/conversions have largely positive influences on the total ecosystem and that potential actions make economic sense. Larger and more frequent fires should be expected in these areas. Reseeding after these fires may offer the main opportunities for re-directing succession in more positive directions.

BIG SAGEBRUSH SHRUBLAND COMMUNITIES



Big sagebrush shrubland communities predominantly occur as a shrubland as opposed to a steppe environment. In this particular case, basin big sagebrush (*Artemisia tridentata* spp. *tridentata*) and Wyoming big sagebrush are the dominant shrubs. A portion of this type (particularly in northern Utah) that occurs on Mollisols may have at one time been regarded as a shrub-steppe, but overgrazing, lack of fire, and soil erosion have reduced the herbaceous component and allowed the big sagebrush to become denser.

Big sagebrush shrubland communities typically occur in broad basins between mountain ranges, plains, and foothills and are spread over 2.7 million acres (Photographs 16 and 17). Soils are typically deep, well-drained and non-saline. Scattered juniper species, greasewood, and saltbushes may be present in some stands. Yellow rabbitbrush and antelope bitterbrush (*Purshia tridentata*) may co-dominate disturbed stands. Perennial herbaceous components typically contribute less than 25 percent vegetational cover. Common grasses include Indian ricegrass, blue grama (*Bouteloua gracilis*), Idaho fescue (*Festuca idahoensis*), needle and thread grass (*Hesperostipa comata*), basin wildrye (*Leymus cinereus*), James' galleta (*Pleuraphis jamesii*), western wheatgrass (*Pascopyrum smithii*), or bluebunch wheatgrass (*Pseudoroegneria spicata*). Although big sagebrush shrublands share some physical and biological characteristics associated with the sagebrush steppe, they differ in the preponderance of sagebrush in the community, on some sites approaching a monoculture. Generally this type lies above salt desert shrub communities and below pinyon-juniper communities in elevation, but can be found intermingled with them in complex patterns.

These communities have seen little sustained human use other than as a source of forage for range livestock, especially by sheep in the winter. It has more recently shifted to cattle use in winter as well as in other seasons. A small amount of the most favorable land has been converted to irrigated agriculture.

The climate on these rangelands is characterized by cold winters, hot summers, and semiarid to arid conditions. Mean annual total precipitation varies from 8 to 12 inches. The soils are usually classified as Aridisols. Relative cover of the sagebrush is usually over 70 percent. The absolute cover, however, is between 10 to 40 percent. Microphytic and/or vesicular crusts often cover interspaces between the shrubs.

Before European men came to the Intermountain West, vegetation was apparently rarely dense enough to carry fire and thus make way for many perennial grasses (West and Hassan, 1985). Now that cheatgrass has entered the scene, fires are common and an even more rapid decline with less chance of recovery is expected here (West et al., 1984) than in the more mesic-related ecosystems.

The flora of this type is usually poor because of the overwhelming dominance of sagebrush. Total aboveground standing crop phytomass in this type can vary between 2 and 12 tons per acre, depending on site and successional differences. Only about 15 to 20 percent is current annual growth, and most of that is due to sagebrush tissues well loaded with secondary chemicals that make them unpalatable to livestock. The average livestock grazing capacities are thus much lower than for the sagebrush steppe. Forage availability apparently increases on areas in poor condition because sagebrush is reduced, and introduced annuals, such as cheatgrass, can actually provide more short-lived forage than the higher condition range.

The native fauna that are present in this ecosystem are reduced compared to the other big sagebrush types, again primarily related to the dominance of sagebrush. Large native ungulates have apparently not been abundant since the end of the ice ages. The major vertebrate herbivore, by far, is the black-tailed jackrabbit. The population fluctuations of this animal may be related to the influences of humans on vegetation and predators. Insects known to visibly affect the vegetation are webworms, psyllids, thrips, grasshoppers, and Mormon crickets (West, 1983b). Other possible influents are harvester ants and cicadas.

This deceptively simple ecosystem was so weakly stable that unrestricted livestock grazing and the introduction of weeds, particularly cheatgrass, have led to successional patterns that may or may not reach new levels of stability in the near future. In other words, this vegetation type has shown poor resilience, and may never again approximate its original structure (West et al., 1984). Soil erosion has been greatly accelerated over the past 130 years. Whether nature or humans should heal the damage remains a critical policy question.

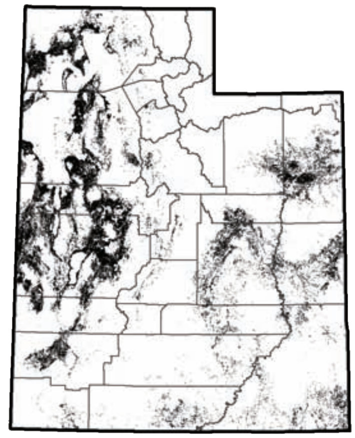
Aboriginal people looked for the sandier or alluvial portions of this type where grasses were more abundant. They harvested the grains from Great Basin wildrye and Indian ricegrass, dug bulbs of forbs in the lily family, and dug root stalks of plants in the celery families. The low productivity prevented the frequent harvest of large ungulates and adoption of a horse-based culture. Native peoples occupied this area at very low densities (West, 1983b).

The early explorers encountered difficulties in traveling through these regions and colonists could develop sustainable settlements only with irrigation systems to enhance the production of a very small but critical fraction of the land. Ranchers had to learn how to grow and store hay to get their livestock through occasionally difficult winters. Sheep were better suited to such ranges than cattle and became abundant in the late 1800s. Such ranges were typically used in the spring and autumn as part of a migratory pattern, including use of deserts in the winter and mountains in the summer. Spring use was very harmful to the herbaceous species and range conditions declined rapidly.

In order to get deferment of use during the spring, the period when desirable forages are most susceptible to damage from livestock, federal researchers brought in grazing-tolerant Eurasian species of wheatgrasses and ryegrasses. The livestock grazing capacities of these seeded pastures are 10 to 20 times that of the native range. Large acreages were converted to introduced grasses in the three decades after 1940. Wildlife managers and environmentalists became concerned about what was happening to the diversity and population levels of wild animals in these seeded areas. There was also worry that the large areas of grass monoculture would be susceptible to insect and pathogen outbreaks. Although these problems have not materialized to any great extent, shrub re-invasion of the seedings has occurred.

The majority of big sagebrush shrubland communities has never been sprayed with herbicide, tilled or seeded, or had much in the way of intensive management. These communities continue to have accelerated soil erosion following extreme events. Cheatgrass has made this type susceptible to wildfire damage, and other weeds, such as halogeton and bur buttercup, are now problems.

SALT DESERT SHRUB COMMUNITIES



Salt desert shrub communities typically occupy lower-lying areas of the semidesert life zone on soils that tend to be saline and calcareous, medium to fine textured, and alkaline. More than 80 percent of the salt desert shrub communities fall in the semidesert life zone (Figure 7.26). There are major subdivisions of this type. The uplands that have well drained Argid or Orthid soil. They are occupied by the euhalophytes, plants that survive on limited soil moisture, largely the saltbushes (*Atriplex* spp.), and particularly shadscale (*Atriplex confertifolia*). The second subdivision consists of hydrohalophytes that are rooted in brackish moisture zones with at least a seasonal water table. These occupy the lowlands around ephemeral lakes in the Great Basin, or along water courses in the Colorado Plateau. They predominantly consist of greasewood (*Sarcobatus vermiculatus*) (Photographs 18, 19, and 20).

The traditional use of this type has been extensive livestock grazing, typically by sheep in the winter when snow is a water source. With the decline of the range sheep industry, these rangelands are being used by cattle in the winter as well as other seasons. Apparently because of low productivity and few competing uses for these lands, an increased tendency to site various nuisance activities in these rangelands has occurred. For instance, a large fraction of these lands in Utah is reserved for military training, material and waste storage, research, and development. Some large power plants have also been sited on salt desert ranges, and perhaps more will be in the future, including solar and wind power sites. Thus to many, these seemingly wastelands are fit only for activities not permissible elsewhere.

Total average annual precipitation on these rangelands varies from 5 to 10 inches. Temperatures are cold in the winter and hot in the summer. The shrubs on upland sites typically grow only in late spring. Shrubs near surface water tables have their main growth period in summer. Late summer-early fall rainy periods in the southeast can produce a flush of growth by warm-season grasses.

Soil salinity aggravates lack of soil moisture. Sodium causes dispersion of soil particles when wet, leading to sealing of surface crusts and more rapid runoff. This is especially a problem on the marine shale-derived badlands of the Colorado Plateau. Few exotic plants can tolerate the combinations of atmospheric and soil-induced aridity.

There are often distinct boundaries within this and adjacent community types. These, at times, are probably due to the sharp changes in salt content related to sedimentary history. In addition, clusters of shrubs are often found on mounds of soil different than the surrounding area.

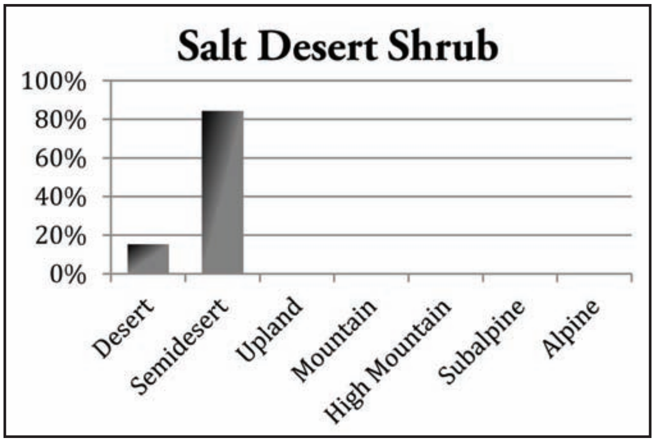


Figure 7.26. Distribution of salt desert shrub communities across life zones.

Floristic lists are short in this type because few plants can tolerate these harsh environments. Some perennial grasses and forbs, largely in the aster and legume families, occur on upland sites. Annual grasses and forbs, mainly in the mustard and goosefoot families, can be seen during years with abundant precipitation.

The height of the shrubs is generally less than 1½ feet, and they are widely scattered in clusters. Total perennial plant cover rarely exceeds 20 percent. The interspaces are often covered with microphytic crusts if animal traffic has not been extreme.

In the group of euhalophytes, dominant shrubs can be separated into two basic groups that tend not to intermingle due to a large degree of soil differences. The first group occurs in relatively coarser textured soils and consists of a mixture of different salt bushes, grasses, and forbs. The second group occurs predominantly on marine shales. These shales consist of the Mancos Formation. The soils are particularly alkaline and fine textured and can only support a few distinct species of plants. Shrubs surviving on the Mancos-derived soils consist predominantly of mat saltbush (*Atriplex corrugata*) and Gardner's saltbush (*Atriplex gardneri*).

The second group of euhalophytes is more diverse and tends to occupy soils that are not as fine textured. Shrubs generally consist of combinations of shadscale (*Atriplex confertifolia*), four-wing saltbush (*Atriplex canescens*), winterfat (*Krascheninnikovia lanata*), spiny hopsage (*Grayia spinosa*), bud sagebrush (*Picrothamnus desertorum*), gray molly (*Bassia americana*), yellow rabbitbrush (*Chrysothamnus viscidiflorus*), Mormon Tea (*Ephedra* spp.), horsebrushes (*Tetradymia* spp.), and Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*). Common grasses consist of Indian ricegrass (*Achnatherum hymenoides*), blue grama (*Bouteloua gracilis*), western wheatgrass (*Pascopyrum smithii*), and alkali sacaton (*Sporobolus airoides*).

Aboveground standing crops of vegetation vary from 0 on the salt flats to about 6 tons per acre on the best upland sites. About half of this or less is production from the current year. There can be an eight-fold difference in production, primarily depending on the precipitation of the previous 12 months. Much of this herbage is not suitable as forage; however, a considerable fraction can be woody, spiny or poisonous, leading to low livestock carrying capacities.

Unrestricted livestock grazing from about 1870 until 1935 led to great reductions in the more palatable and nutritious half shrubs such as winterfat, budsage, and gray molly (West, 1983c). The less palatable species such as shadscale and yellow rabbitbrush increased. Shadscale was, however, negatively affected by drought. Recovery of grazing capacity after excessive grazing and drought has been slow (West, 1983c).

The only large native mammal making regular, if marginal, use of these rangelands is the pronghorn. Rodents and jackrabbits make up the bulk of the users. The only game bird of importance is the introduced chukar partridge. This bird, however, thrives only near rocky escape cover. It eats the winter annuals throughout the colder months. There are numerous small birds who pass through the area, but only the horned lark stays and reaches any abundance.

Invertebrates have largely been ignored. The most conspicuous are the harvester ants that can denude 5 to 10 percent of these ranges for their mounds. Occasional loss of browse plants has been attributed to round-headed borers or cutworms (West, 1983c).

Fires have not been a factor in altering salt desert shrub vegetation until recently when an influx of annuals became more noticeable (Rogers, 1982). Major annuals are the mustards (*Sisymbrium altissimum*, *Descurainia pinnata*), cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola kali*), peppergrass (*Lepidium perfoliatum*), bur buttercup (*Ranunculus testiculatus*), and halogeton (*Halogeton glomeratus*). The latter two have been the biggest worry because they are poisonous to livestock.

The best microsites for plant regeneration are the nutrient-enriched mounds where pedestals of shrubs occur or did occur. Destruction of many of these "islands of fertility" may make regeneration very difficult. Soil erosion is naturally rapid in these areas because there is so little plant cover to protect it. Salt loading of the Colorado River is greatly augmented by arroyo formation in the Colorado Plateau. It is doubtful, however, that reductions in livestock grazing would make much difference because the natural rates of erosion are so great, and potential plant cover is below the threshold for positive feedback.

This ecosystem type was lightly used by native people because there was very little to hunt or gather. Livestock grazing by Europeans started later in these communities than on the previously discussed types. So little water was available in these communities that sheep grazing had to occur during the winter. The great demand for wool during World War I led to drilling of wells so that ranges could be grazed year around. Such areas quickly degraded to bare, blowing sores upon the land. As water hauling later came into play, there was a tendency to graze into the spring growing season. Because most of the desirable forage species die when more than about 40 percent of their new leaves and twigs are removed, late spring grazing was destructive.

The process of adjusting livestock numbers to carrying capacity was initiated in the 1930s, but not really accomplished until the 1950s. By then, halogeton had spread. It took this scare to begin adjusting numbers and season of use. The only feasible way to prevent halogeton from spreading is to keep the range in good condition. Halogeton is not very competitive and requires disturbed sites to thrive.

Unfortunately, the decline of the sheep industry has led to attempts to graze these browse-dominated ranges with cattle. However, only cattle that are bred for such conditions do well. Blaisdell and Holmgren (1984) are convinced that concentration of grazing in the winter and rotation of spring use, interspersed with rest, will lead to improved range conditions. It should be pointed out that all of their evidence comes from sheep-grazed ranges that have always been in higher condition than most of this type. Without means to consistently and economically repair damage by seeding, however, careful grazing management is the only hope to improve these lands.

DESERT ZONE

The desert zone is the lowest elevation life zone occurring in Utah, found at approximately 2,050 feet to 5,063 feet elevation. This zone occupies just over 6 million acres or 11 percent of the state. There are two major places this zone occurs: in the lowest portions of former Lake Bonneville in the West Desert and near the Green River and Colorado River in the southeast. A smaller portion of this life zone is found in the extreme southwestern portion of the state where the Mojave Desert extends into Utah.

Mean annual precipitation ranges from 1.4 inches in the fall to 2.4 inches in the winter for a yearly average of 7.5 inches. There is an increase in precipitation in the southwestern and southeastern portion of this zone during the late summer due to monsoonal storms originating in the Gulf of California. Mean annual temperatures are the warmest, ranging between 36 degrees Fahrenheit to 74.6 degrees Fahrenheit from winter to summer. The growing season is also the longest, starting in late March-early April and extending to the end of October (Figure 7.27). While the growing season may be longer than any other life zone, water is very limiting since the reference evapotranspiration (RET) is higher than precipitation for every month except January, where the RET is roughly equal to precipitation (Figure 7.28).

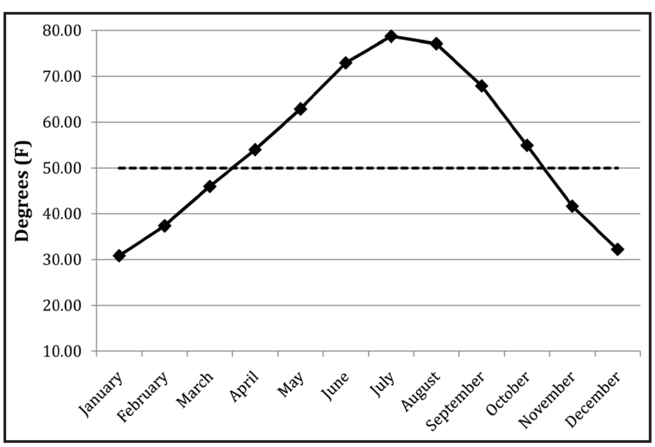


Figure 7.27. Average monthly temperatures within the desert zone showing number of months with average temperatures over 50 degrees Fahrenheit. Extracted from Daymet climate models (Thornton et al., 1997).

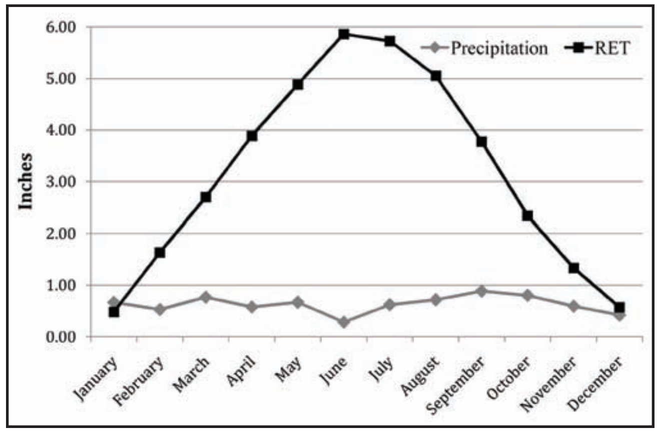


Figure 7.28. Monthly distribution of precipitation within the desert zone contrasted with modeled reference evapotranspiration (RET). Extracted from Daymet climate models (Thornton et al., 1997).

The desert zone in extreme western Utah is dominated by playas, the bottoms of former lakes. The high concentration of salts in the nearly flat terrain contributes to the paucity of vegetation and lack of soil development. The Green River and Colorado River portions are dominated by tablelands and blackbrush-Mormon tea communities. The extreme southwestern portion of the state consists of the Mojave Desert, and the characteristic vegetation is unique to the state, consisting of mesquite, Joshua tree (typically found with blackbrush), and creosote-white bursage communities.

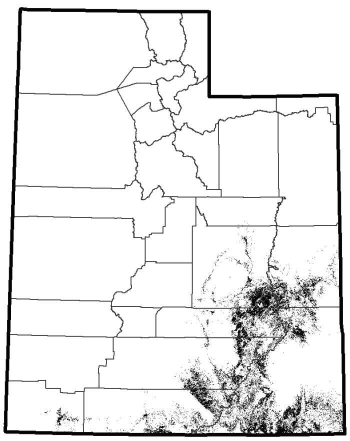
The deserts around the lower Green and Colorado river drainages, in addition to being atmospherically dry, are effectively dry because of additional influences. First, the sandstones under such dry conditions may have such little vegetated that geologic erosion keeps bare rock exposed. This is locally called slick rock. The shales which are also prevalent in this portion of the life zone are exposed beds of ancient seas. Because they are so salty and impenetrable to rainfall, few plants can occupy them and hold and build soil. The result is development of badland topography. In other places, gypsum-bearing rocks have led to crusted soil surfaces also inhibiting plant and soil development.

This life zone is composed of a relatively short list of community types when compared to the other life zones with the exception of the alpine zone. Tablelands composed of sandstone slick rock cover 25 percent of this zone, followed by blackbrush-Mormon tea communities (23 percent) (Table 7.8). Salt desert shrublands are also common here, but the majority of this type occurs in the semidesert zone. The portion of salt desert shrubs that occur here are similar to what occurs in the semidesert zone, but with lower productivity. As far as MLRAs are concerned, the desert life zone can mostly be found within the Colorado and Green River Plateaus (70 percent), the Great Salt Lake Area (23 percent), and the Mohave Basin and Range (2 percent). Given the unique nature of this life zone, the blackbrush-Mormon tea will be discussed, along with the creosote-white bursage occurring in the Mojave Desert.

Table 7.8. Distribution of generalized SWReGAP land cover types across the desert zone in Utah. The miscellaneous category is the sum of all other land cover types occurring less than 2 percent over the area of the life zone.

LANDCOVER	ACRES	PERCENT
Tableland	1,481,931	25
Blackbrush-Mormon Tea	1,401,045	23
Salt Desert Shrub	1,050,575	17
Playa	952,188	16
Dune	270,754	4
Creosote-White Bursage	181,421	3
Miscellaneous	725,684	12
TOTAL	6,063,598	100

BLACKBRUSH-MORMON TEA COMMUNITIES



Blackbrush-Mormon tea communities occur mostly in the desert zone (63 percent) with the remainder in the semidesert zone (Figure 7.29). These communities are mainly on well-drained benchlands, colluvial slopes, pediments, or bajadas, with a strong affinity to shallow, calcium-enriched Paleosols. These communities are extensive open shrublands dominated by blackbrush (*Coleogyne ramosissima*) with Mormon tea (*Ephedra viridis*), Torrey joint fir (*Ephedra torreyana*), and spiny hopsage (*Grayia spinosa*). Sandy portions may include sand sagebrush (*Artemisia filifolia*). Microphytic crusts are abundant in the interspaces where livestock or human traffic has not been excessive (Photographs 21 and 22).

The lands within these communities that are not completely isolated or poorly watered can be used for some seasonal livestock grazing. Much of the type is isolated by deep canyons and mesas and is rarely visited.

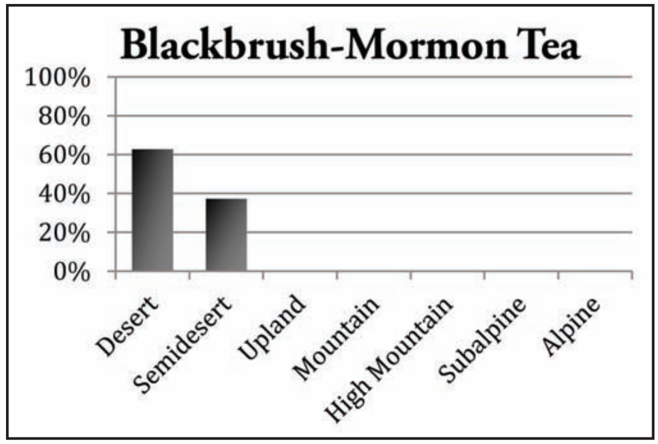


Figure 7.29. Distribution of blackbrush-Mormon tea communities across life zones.

Growth rates of blackbrush are extremely slow (West, 1983e). Only the sites with deeper soils have much in the way of grass available for animal use. These sites generally occur in the semidesert zone where moisture is in greater supply. The best time to utilize these ranges is in the early spring when protein from the grasses is much higher. The bulk of the type is, however, not highly regarded for livestock production.

There are not many species of plants that can tolerate the rigors of this environment. A total species list for representative samples would not include more than a dozen species, even with the spring annuals. Other than the aforementioned dominant shrubs, the following can also be found: desert almond (*Prunus fasciculata*), turpentine bush (*Ericameria laricifolia*), and if disturbed, broom snakeweed (*Gutierrezia sarothrae*). Some occasional yucca and cacti may also be found on some sites. Joshua tree (*Yucca brevifolia*) is frequently associated with blackbrush in extreme southwestern Utah.

The perennial herbaceous component is limited to a few bunchgrasses, such as Indian ricegrass (*Achnatherum hymenoides*), James' galleta (*Pleuraphis jamesii*), sand dropseed (*Sporobolus cryptandrus*), big galleta (*Pleuraphis rigida*), threeawn (*Aristida* spp.), needlegrasses (*Achnatherum aridum* and *Achnatherum speciosum*), and gramas (*Bouteloua eriopoda* and *Bouteloua gracilis*). The density of these grasses is strongly related to soil depth, with abundance of grass increasing with soil depth (West, 1983d).

Annuals can be abundant for about 6 weeks in the spring during wet years, but composition and production vary greatly, making them undependable for forage and cover. Only opportunistic use can be made of this community during this time. Given the resinous nature of blackbrush and the high cover of vegetation, wildfires are a common threat.

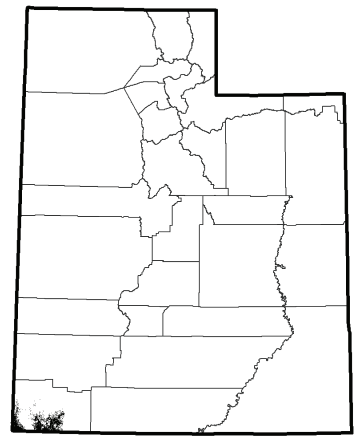
Because of dominance by blackbrush and its relatively poor palatability and nutrition, livestock grazing capacities are very low. Livestock grazing has caused a decline of the perennial grass component on sites with deeper soils. More profound changes occur, however, following fire. Blackbrush does not resprout after fire, and even regeneration from seedlings is rare. Post fire vegetation is usually dominated by less desirable shrubs (turpentine bush, snakeweed) and introduced annual grasses, namely red brome (*Bromus rubens*) and cheatgrass, which are less dependable as forage and have effectively reduced fire return intervals. Accelerated soil erosion frequently follows burning. Reestablishment of the original dominants after mechanical disturbance is also very slow (West, 1983d).

Blackbrush is the keystone species and plays a critical role in maintaining the structure of this community. The vegetation that comes in after fire or other disturbance varies much more erratically in species composition and production. Because fires usually occur in the summer, the land may be unprotected for several months before winter annuals germinate. With the introduction of red brome or cheatgrass, chances of reburning increases and thus a downward spiral of degradation may set in. This degradation is of great concern in these areas because soils are typically shallow. A small, erosional loss at the surface results in a greater percentage loss of the total soil profile than in other types. Thus, if wildfires are allowed to burn uncontrolled, permanent loss of the potential for the land to produce vegetation in the future may occur. It is thus probably best to restrict attempts at improvement to sites with deep soils and control fires elsewhere in the type. There is little evidence that extant grazing systems improve range condition (West, 1983d), and recovery after removal of livestock is very slow (Jeffries and Klopatek, 1987).

The fauna of these areas is a mix of Great Basin and Mojave Desert elements. Because this vegetation forms an important part of its winter range, the only native ungulate of any importance is the desert bighorn sheep. Snakes are relatively abundant here, probably related to the abundance of seed-eating rodents and warmer temperatures of the region.

Aboriginal people made very few marks on this land. European influences also came relatively late. Roads into blackbrush-Mormon tea communities were lacking until the uranium exploration boom of the 1950s. Cattle generally do poorly on these ranges, but sheep or goats can utilize blackbrush.

CREOSOTE-WHITE BURSAGE COMMUNITIES



Creosote-white bursage communities occur in the hottest, driest valleys, bajadas, and low hills in the Mojave Desert portion of Utah. Soils are well-drained and caliche deposits at 15 to 20 inches deep are commonly covered with lag gravel called desert pavement. According to the SWReGAP land cover dataset, this type occurs more frequently in the semidesert zone (Figure 7.30). However, these communities are restricted and more characteristic of the Mojave Desert portion of Utah. Creosote-white bursage communities are characterized by sparse to moderately dense vegetation cover (2 to 50 percent). Creosote bush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*), also known as burrobush, are the dominants. Many different shrubs, dwarf-shrubs, and cacti may co-dominate or form typically sparse understories (Photographs 23 and 24).

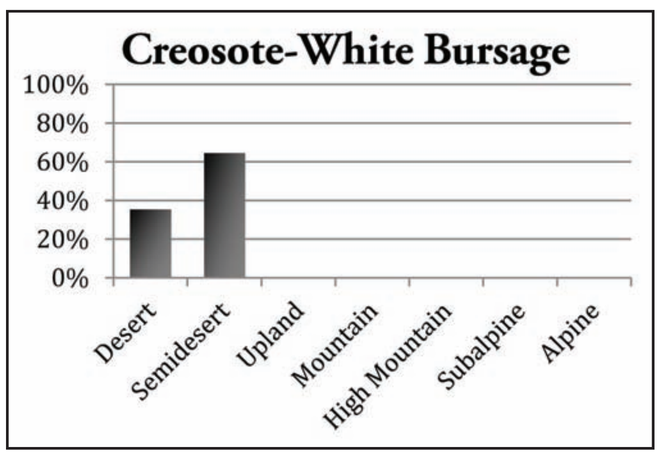


Figure 7.30. Distribution of creosote-white bursage communities across life zones.

Livestock grazing was the historic land use and it continues to be the major use of these lands. Livestock are put on these ranges in winter and left until early spring, especially in wet years when ephemeral forage is abundant.

The flora of these deserts is mostly composed of annuals, and their composition varies greatly from year to year. Many are too short in stature to be of use to ungulates. The perennial flora is very limited on the upland sites. Associated shrubs may include four-wing saltbush (*Atriplex canescens*), desert holly (*Atriplex hymenelytra*), brittlebush (*Encelia farinosa*), Nevada jointfir (*Ephedra nevadensis*), ocotillo (*Fouquieria splendens*), water jacket (*Lycium andersonii*), beavertail pricklypear (*Opuntia basilaris*), wolfberry (*Lycium torrey*), and dalea (*Psorothamnus fremontii*). The herbaceous layer is typically sparse, but may be seasonally abundant with ephemerals. Herbaceous species such as desert trumpet (*Eriogonum inflatum*), threeawn (*Aristida* spp.), Cryptanthas (*Cryptantha* spp.), phacelia (*Phacelia* spp.), bush muhly (*Muhlenbergia porteri*), and big galleta (*Pleuraphis rigida*) can be found, usually under the shrubs.

Primary production in these ecosystems is low due to the wide spacing of the shrubs with widely ramifying root systems and scanty occurrence of other perennials in the interspaces. The annuals put 30 to 50 percent of their aboveground production into seeds. The shrubs can grow through the winter, whereas the herbaceous species make a burst of growth in the spring and again after any large rainstorms.

Succession is best described as auto-succession because so few perennials can exist here that the same ones come in after disturbance as were there originally. Because of low production, mainly creosote bush tissues that are unpalatable to livestock, as well as widely scattered and undependable water supplies, the livestock grazing capacities are around 0.01 animal unit months (AUMs) per acre per year. Lack of water for livestock has apparently prevented the deterioration typical of more mesic areas.

Despite the low primary productivity, the fauna are surprisingly diverse on these ranges (MacMahon and Wagner, 1985). There are many small mammals that either live off the reserves of seeds or predate on the seed eaters. These areas also have the greatest variety of snakes and reptiles, such as the desert tortoise, of any area in Utah.

Because of the harshness of this environment, impacts upon it are slow to heal. Fortunately, vegetation is rarely thick enough to make fuel for wild fires. Natural erosion has typically already produced the self-protecting desert pavement. Few introduced plants have become serious weeds in these environments.

Until the advent of super-highways and air-conditioned conveyances and homes, it has been difficult for humans to travel through or live on these lands. Consequently, major impacts have largely been limited to the last few decades. There were a few itinerant graziers of sheep in the early part of the 20th century. Options for measurable improvement have been almost nonexistent. Short water supplies have also greatly limited conversions to intensive agriculture.

These environments have seen significant urbanization in the last few years. The 2008 population of Washington County was estimated to be approximately 137,500. This is an increase of over 47,000 people since 2000. In 2007, this area, particularly St. George, Utah, was named by the United States Census Bureau as the fastest growing metro area in the nation, with a 6-year growth rate of 40 percent. The St. George Chamber of Commerce has estimated that the population will grow to 607,334 by 2050, given current trends. This current and projected growth will have significant impact on the natural landscape through urbanization and the recreational impacts of the population. Since water is a significant limiting factor, it should logically reduce future growth. However, to date, it seems that limited water availability has not hindered population growth.

Photograph 1
Alpine Bedrock and Scree
High Uintas

Photograph 2
Alpine Fell Field
Mt. Ellen, Henry Mountains

Photograph 3
Alpine Tundra
High Uintas

Photograph 4
Alpine Dwarf Shrub
High Uintas

Photograph 5
Spruce/Fir Forest
Bear River Range
Cache National Forest

Photograph 6
Lodgepole Pine Forest Understory
South Slope of the High Uintas

Photograph 7
Lodgepole Pine Forest
North Slope of the High Uintas

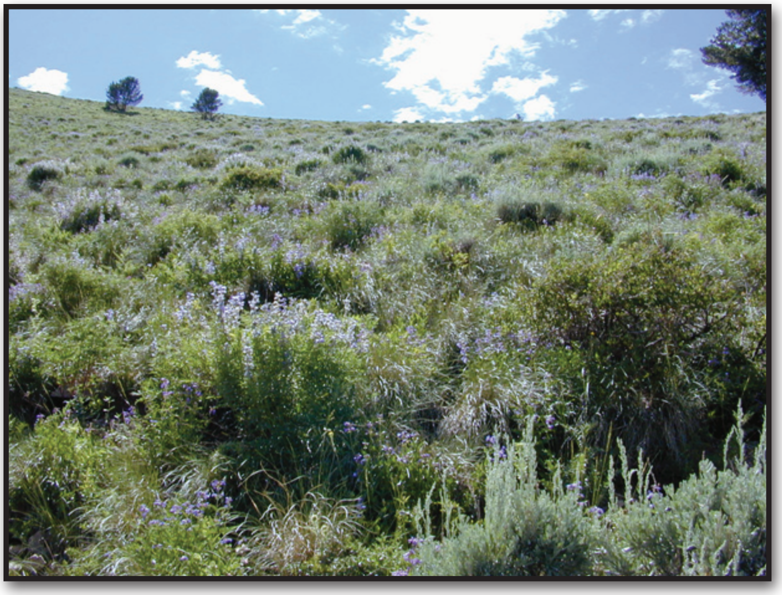
Photograph 8
Mountain Big Sagebrush
Uinta National Forest

Photograph 9
Aspen Forest
Stansbury Mountains
Wasatch National Forest

Photograph 10
Ponderosa Pine Forest
Aquarius Plateau
Dixie National Forest

Photograph 11
Ponderosa Pine Forest
East Slope of the La Sal Mountains
Manti-La Sal National Forest

Photograph 12
Gambel Oak Community
Oquirrh Mountains
Wasatch National Forest



Photograph 13
Big Sagebrush Steppe Community
Mt. Ellen
Henry Mountains

Photograph 14
Pinyon-Juniper Woodland
Oquirrh Mountains

Photograph 15
Pinyon-Juniper Woodland
Grand Staircase-Escalante
National Monument

Photograph 16
Big Sagebrush Shrubland
West of Kanab, Utah

Photograph 17
Big Sagebrush Shrubland
Canyonlands National Park

Photograph 18
Mat Saltbush
Near Emery, Utah

Photograph 19
Mixed Salt Desert Shrub
Great Basin, Utah

Photograph 20
Greasewood Community
Uinta Basin, Utah

Photograph 21
Blackbrush-Mormon Tea Community
South of Wahweap Marina, Lake Powell
Kane County, Utah

Photograph 22
Blackbrush-Mormon Tea Community
West of Wahweap Marina, Lake Powell
Kane County, Utah

Photograph 23
Creosote-White Bursage Community
Southwestern Utah

Photograph 24
Creosote-White Bursage Community
Southwestern Utah

LIVESTOCK GRAZING IN UTAH

Roger E. Banner

LIVESTOCK NUMBERS

The number of beef cows in Utah has nearly doubled since 1920, while the number of ewes rose to a peak in 1930 and declined by 89 percent since then (Figure 8.1.1). One way to better understand the implications of increases or decreases in different species of animals in relation to forage demand is to convert the total number of animals to animal units (AUs). This conversion is based on the assumption that one AU is equivalent to a 1,000 pound animal, which translates to one cow or five ewes. Although cow numbers have increased markedly since 1920, the total number of animal units (AU) of beef cows and ewes has declined by approximately 26 percent as a result of the dramatic decline in sheep numbers (Figure 8.1.2). Given the fact that beef cows have become progressively larger in body size since 1920, this decline may be more related to an increase in average cow size over the period than to an actual decrease in capacity.

The increase in beef cow numbers in Utah has occurred in almost all Utah counties with Box Elder County having the highest numbers. However, Kane, Grand, and San Juan counties are exceptions in that beef cow numbers in these counties are declining. Kane, San Juan, and Grand counties have relatively small amounts of private land, which may not support increasing cattle numbers. It is apparent that some ranchers in counties, such as Utah, Sanpete, Summit, Carbon, Uintah, and Iron, as well as Box Elder (traditionally centers for sheep production), switched to or reallocated their resources to include cattle production (Figures 8.1.3 and 8.1.4).

The decline in the sheep industry in Utah, which has been dramatic in Iron, Sanpete, and Utah counties, reflects the decline in demand for wool, consumer preference for lamb, more restrictive predator control policies, and difficulties in obtaining labor. In addition, most sheep are no longer trailed to and from seasonal ranges and the cost of trucking has likely played a role in the decline of the sheep industry by increasing production costs. The steady decline in sheep numbers has also resulted in many federal grazing permits being transferred from sheep to cattle. Although actual numbers of sheep and lamb losses to predators have declined from about 53,000 animals in 1987 to 29,300 in 2007, the apparent decline in predation losses is confounded by the declining number of sheep. The percentage of losses has remained 10 to 12 percent over the past 20 years. Approximately 80 percent of the annual loss is from loss of lambs, the primary sale product, with the remainder of the loss occurring in breeding herds. The decline in the sheep industry and other factors, such as fire control policies of the past 100 years, are thought by some to have contributed to the gradual increase in woody plant domination on Utah rangelands.

LIVESTOCK GRAZING ON FEDERAL AND STATE TRUST LAND

The Bureau of Land Management (BLM) and the United States Forest Service (USFS) manage most of the federal land in Utah. BLM-administered lands are lands that were in the public domain that had not been included in the national forest system nor taken into private ownership under the homestead acts. The Federal Land Management and Policy Act of 1976 repealed the homestead acts and other settlement acts, closing land administered by BLM to homesteading (Muhn and Stuart, 1988). With this background, it is understandable that most land administered by BLM is often rugged, of relatively low productivity, generally dominated by shrubs or desert vegetation, located in areas of low precipitation, unsuited to farming, and of limited value in terms of timber resources. In Utah, it is generally seasonal range used in fall, winter, or spring. Conversely, national forests are generally found at higher elevations with higher precipitation, the landscape is dominated by forest vegetation, and the land is relatively productive. Forest Service grazing allotments are generally used as seasonal range for livestock grazing in the summer.

The Utah School and Institutional Trust Lands Administration (SITLA) administers approximately 3.5 million acres of Trust Lands (sections 2, 16, 32, and 36), which, for the most part, are dispersed through land administered by BLM for the benefit of schools and other institutions that are trust beneficiaries. Trust land and some private lands within BLM land, called in-holdings, are often managed along with BLM lands under exchange of use agreements. When the scattered trust land sections have been blocked together as a result of land exchanges with the federal land management agencies, SITLA assumes the management. There are few, if any, scattered trust land parcels within national forest or lands taken into private ownership through homesteading or sales. Little livestock grazing occurs on lands administered by other state and federal agencies such as the Utah Division of Wildlife Re-

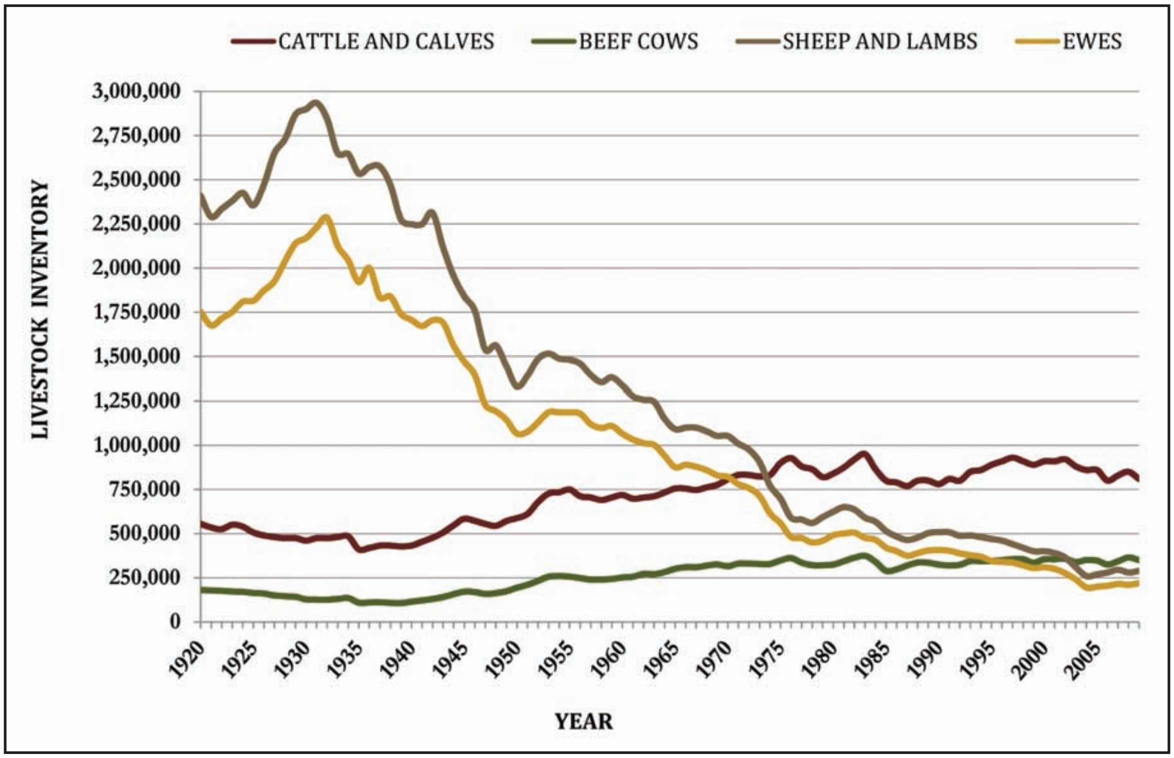


Figure 8.1.1. Livestock inventory in Utah from 1920 to 2009.
Source: National Agricultural Statistics Service (NASS).

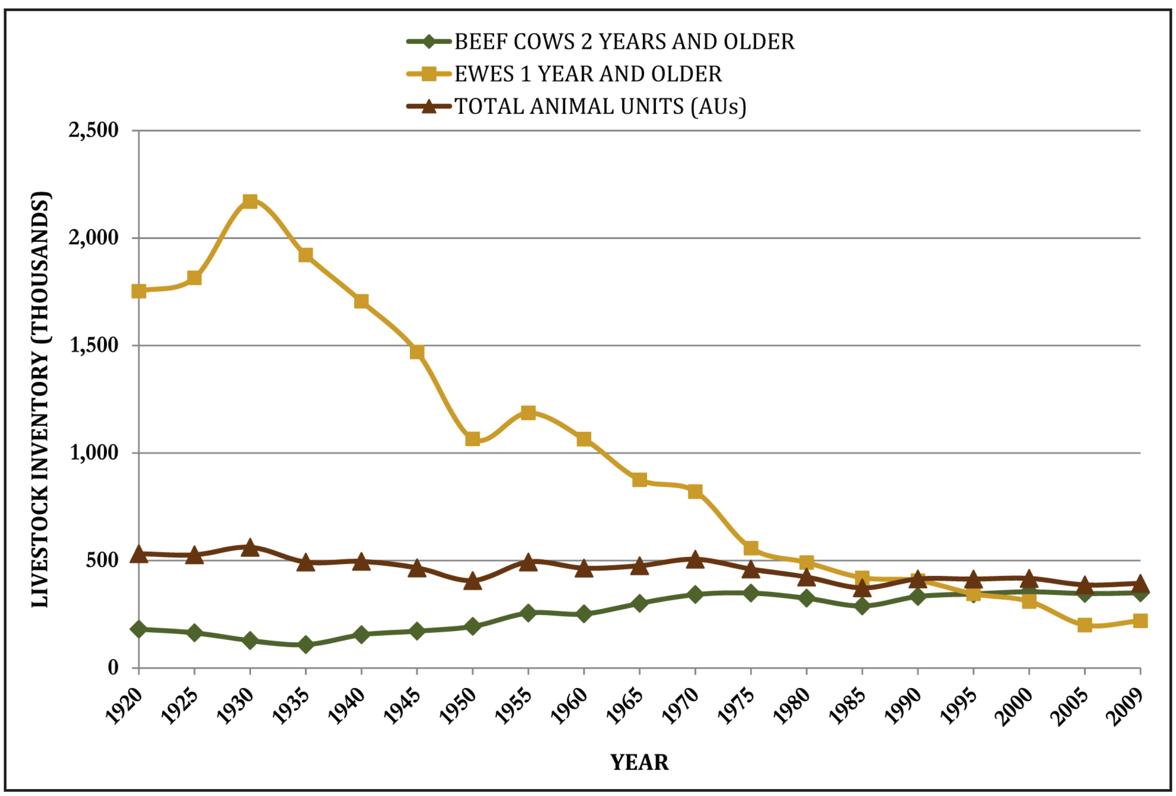


Figure 8.1.2. Trend in beef cows, ewes, and total animal units in Utah from 1920 to 2009.
Source: National Agricultural Statistics Service (NASS).

Figure 8.1.3. Cattle and calves inventory in 2007 by county.

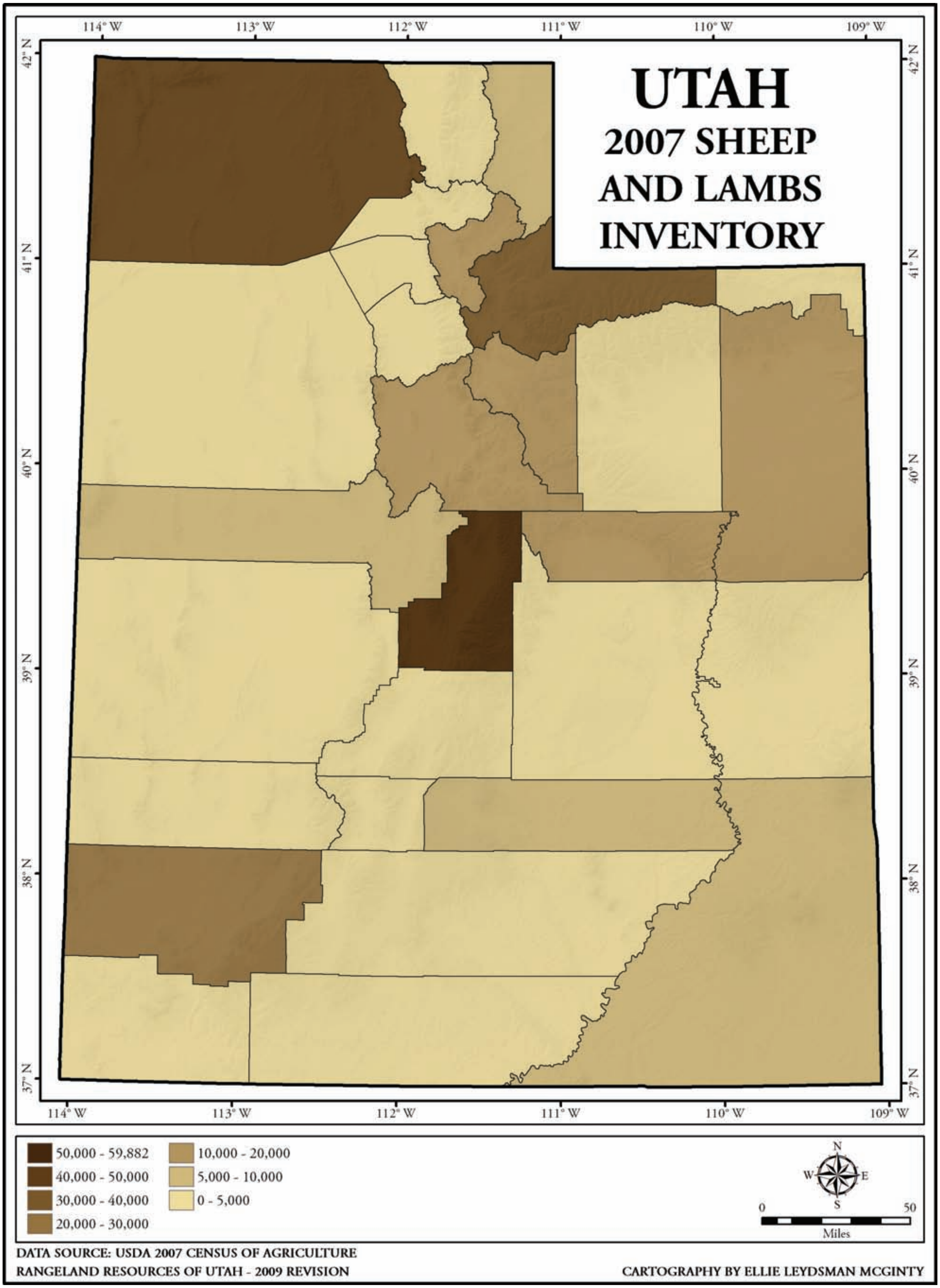


Figure 8.1.4. Sheep and lambs inventory in 2007 by county.

sources, the Utah Division of Parks and Recreation, the Department of Defense, and the National Park Service.

The land management agencies set stocking rates on grazing allotments (Figure 8.1.5) and administer grazing permits held by livestock producers. The permit is divided into two categories: 1) active preference, which may be licensed for grazing use, and 2) suspended preference, which is unavailable for use. Each year, grazing use must be licensed by the BLM. The amount of livestock grazing that actually takes place on BLM-administered rangelands and the amount that is paid is called licensed use. It is determined annually by the land manager based on environmental conditions and other circumstances. The licensed use is restricted to amounts of use equal to or less than the active preference. In order for animal unit months (AUMs) in suspended preference to be used, they must be formally reinstated into the active preference category by the agency manager.

Livestock grazing use on BLM-administered land has declined from 2,749,000 AUMs in 1940 to less than 1,000,000 AUMs currently, a decline of 63 percent (Figure 8.1.6). Much of that decrease came as licensed use decreased in the 1940s, 1950s, and 1960s, with permit reductions associated with adjudication programs to bring livestock stocking rates in line with carrying capacity of allotments.

Grazing permits on BLM-administered rangeland were reduced rather dramatically over several decades after the Taylor Grazing Act of 1934 was passed. Permit reductions in Utah began to level out in the 1960s and 1970s at about 1,250,000 AUMs, which included a substantial amount of grazing preference (AUMs) held in suspended use and unavailable for licensing (Figure 8.1.7). This was in response to excessive grazing use of the public domain prior to and immediately after passage of the Taylor Grazing Act and establishment of the Grazing Service, predecessor to the BLM. Suspended use represents a formal reduction in permit (AUMs) that remains with the permit under the assumption that when and if forage production increases, some or all of the suspended AUMs could be reinstated to active preference. Licensed use and suspended use, when summed, may equal active preference. However, they often do not if drought or other conditions do not support full use of active preference. For example, licensed use was curtailed on BLM-administered land in Utah during the drought years of 2003 to 2005.

Grazing permit reductions continue on BLM land. Active preference has decreased by about 6 percent over the past 12 years. This has occurred for a variety of reasons, including interpretation of BLM policy guidelines; closing of allotments or portions of allotments for wildlife benefit, recreation conflict, watershed health, erosive soils, riparian enhancement, cultural resource conflict; and special area designations, such as Areas of Critical Environmental Concern, specific recreation areas, and area restrictions associated with population goals for some wildlife.

Livestock grazing fees are one of several sources of revenue from BLM-administered lands in Utah and are relatively stable in nominal terms. Recreation, oil, and gas extraction, and minerals lease-related sources are increasing, with recreation receipts increasing over 250 percent since 1997. BLM receipts allocated to state and local governments in Utah have doubled in nominal terms from approximately $10,000,000 in the mid-1990s to approximately $20,000,000 in 2005. These payments and other revenue sharing represent only about 33 percent of the tax liability the federal government would have if it paid taxes at the rate state and local governments collect for such services as law enforcement, education, road construction and maintenance, fire protection, and others (Schuster et al., 1999).

Livestock grazing on national forests was curtailed much earlier than on the public domain, depending on when various forests were formally established. Forest reserves were established and restrictions on livestock grazing were implemented early on as a result of public outcry in the 1890s about serious erosion problems and flooding of communities along the mountains.

National forests in Utah provide a disproportionate amount of livestock grazing compared to BLM-administered land, almost an equal number of AUMs on 35 percent of the land area. This reflects the differences in land productivity between land administered by the Forest Service and land administered by the BLM. The Forest Service reports authorized livestock grazing which reflects variable amounts of licensed grazing over the last 20 years (Figure 8.1.8). It also reflects decreased livestock grazing in response to drought conditions that existed in Utah from 2002 to 2005.

The Forest Service, like the BLM, also returns receipts to Utah in support of state and local government efforts to provide services such as public safety, road construction

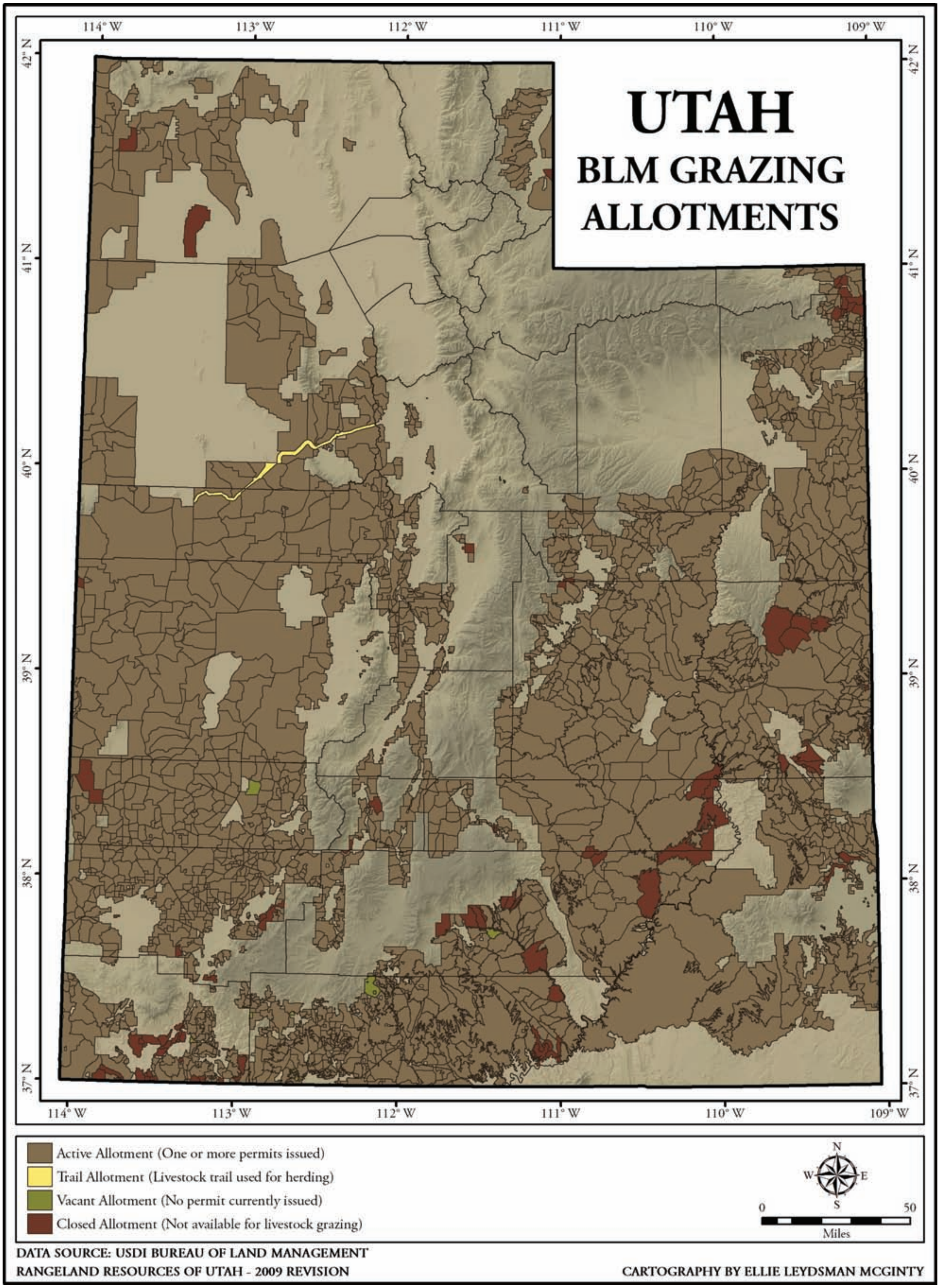


Figure 8.1.5. Bureau of Land Management grazing allotments.

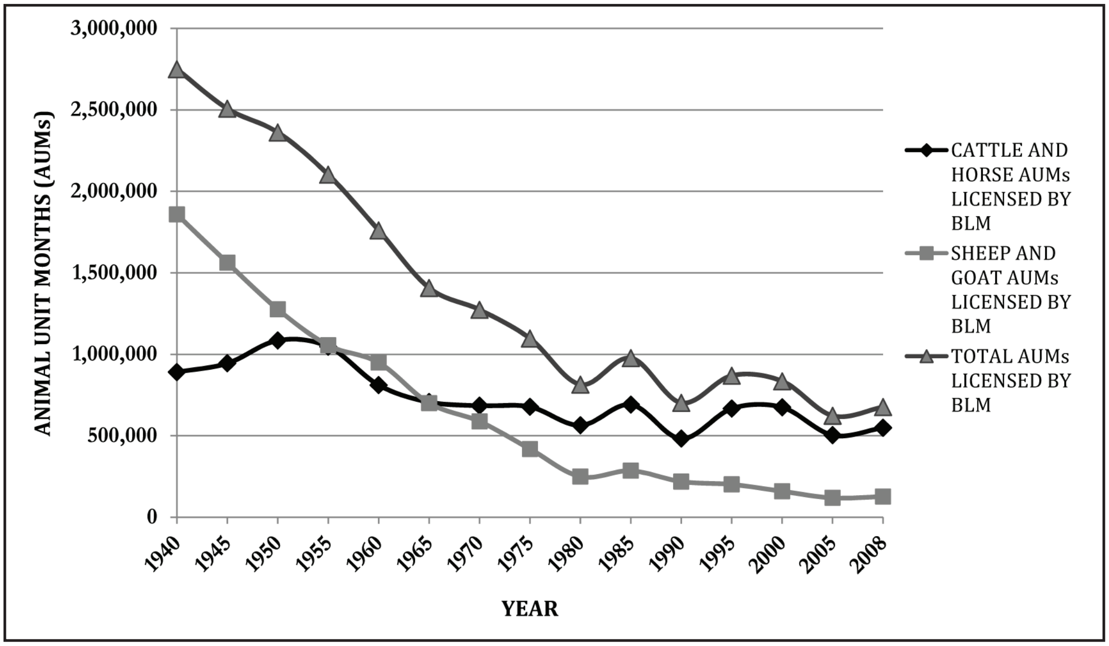


Figure 8.1.6. Trend in AUMs of livestock grazing licensed by the BLM in the state of Utah (1940-2008). Sources: BLM Rangeland Administration (1990-2008), Public Land Statistics (1996-2008), BLM Facts and Figures for Utah (1981-1994). Reference Table 1 in Appendix C.

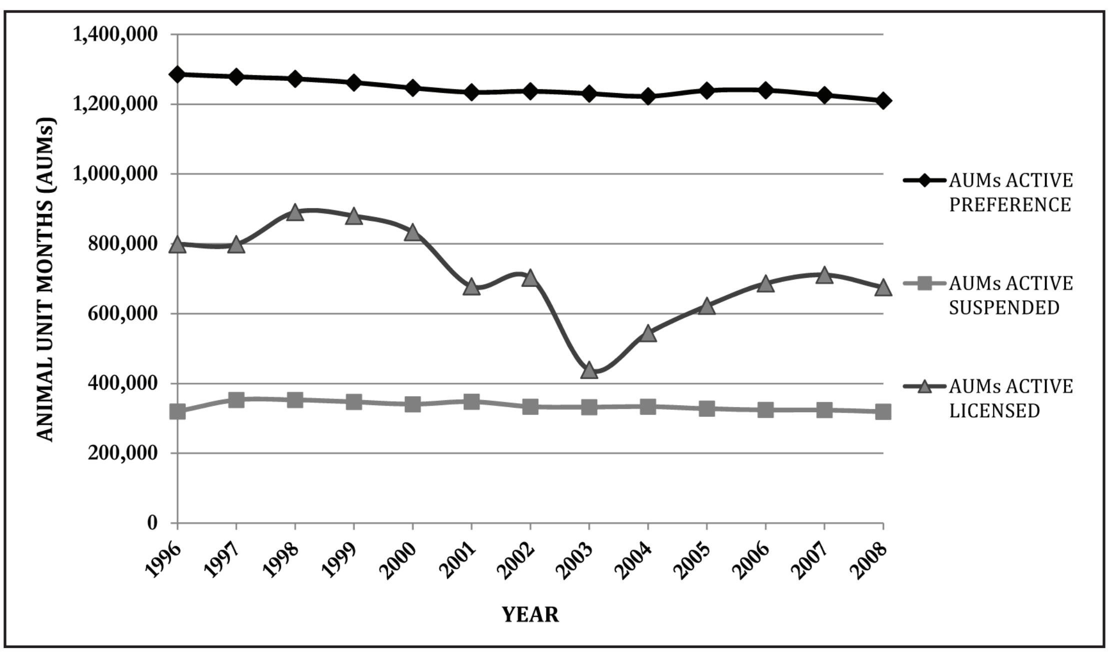


Figure 8.1.7. Trend in AUMs of livestock grazing permitted by the BLM in the state of Utah (1996-2008). Sources: BLM Rangeland Administration (1990-2008), Public Land Statistics (1996-2008). Reference Table 2 in Appendix C.

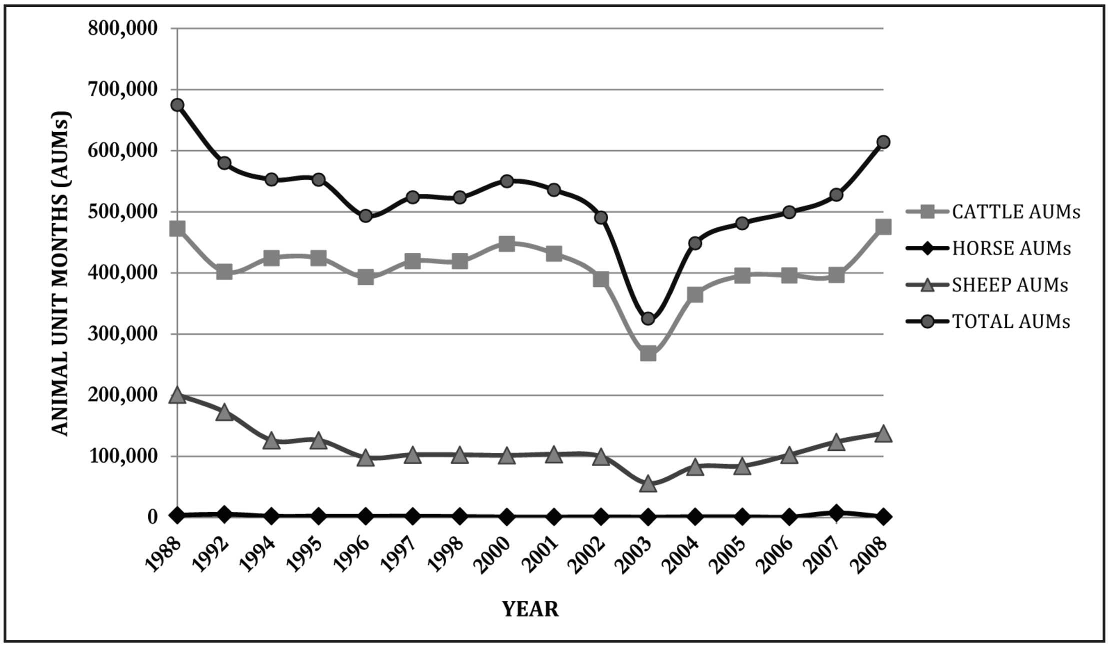


Figure 8.1.8. Trend in AUMs of livestock grazing authorized by the USFS in the state of Utah (1988-2008). Note: AUMs estimated from reported HMs by species (Cattle=1.25 AU; Sheep=0.20 AU; Horses=1.25 AU). Sources: Report of the Forest Service (1988-2008), Grazing Statistical Summary Reports (2000-2008). Reference Table 3 in Appendix C.

and maintenance, education, health services, law enforcement, and more.

LIVESTOCK FEED PRODUCTION

Acreage devoted to production of grains and forages for livestock has increased from 737,000 acres to over 853,000 acres in Utah since 1940. Changes in irrigation technology have likely contributed to making this 16 percent increase in acreage possible. Total harvested cropland reported in the 2002 Census of Agriculture was 961,037 acres. Increasing cost of equipment, energy, or other factors, such as commodity prices, land productivity, or lack of irrigation water may have rendered some of the more marginal cropland uneconomical. The amount of productive cropland in Utah is very limited. Approximately 692,000 acres of the total 844,000 acres, or 82 percent, of irrigated land acreage in Utah is classified as land with low to marginal production potential (Types Irrigated III and IV).

Corn silage and grain acreage increased from 1940 to 1980, but has stabilized or fallen slightly in recent years. Oat and barley acreage averaged 175,000 acres until 2007 when it dropped to less than half of former acreages. This could be related to increased production of crops, like canola on land formerly devoted to small grain. Alfalfa and other hay acreage have increased by 32 percent since 1940.

LIVESTOCK INDUSTRY RECEIPTS

Utah agriculture is dominated by production of livestock, livestock products, and the production of feed crops utilized in the livestock industry. In nominal terms, agricultural receipts in Utah have increased from $588 million in 1984 to $1.3 billion in 2007, a 128 percent increase, while Utah livestock and livestock product receipts have also more than doubled in the same period. The implication is that livestock and livestock receipts have fairly consistently contributed from 71 to 78 percent of all agricultural product receipts over the last 24 years (Figures 8.1.9, 8.1.10, and 8.1.11). Beef cattle, dairy cattle, swine, and sheep, in decreasing order, contribute the majority of Utah livestock receipts. In terms of receipts from live animal sales, the cattle and sheep industries' contributions vary from 68 to 79 percent, while the swine industry contributions vary from 20 to 30 percent. Swine production contributions have increased dramatically to $144 million in 2007 from about $6 million in 1995.

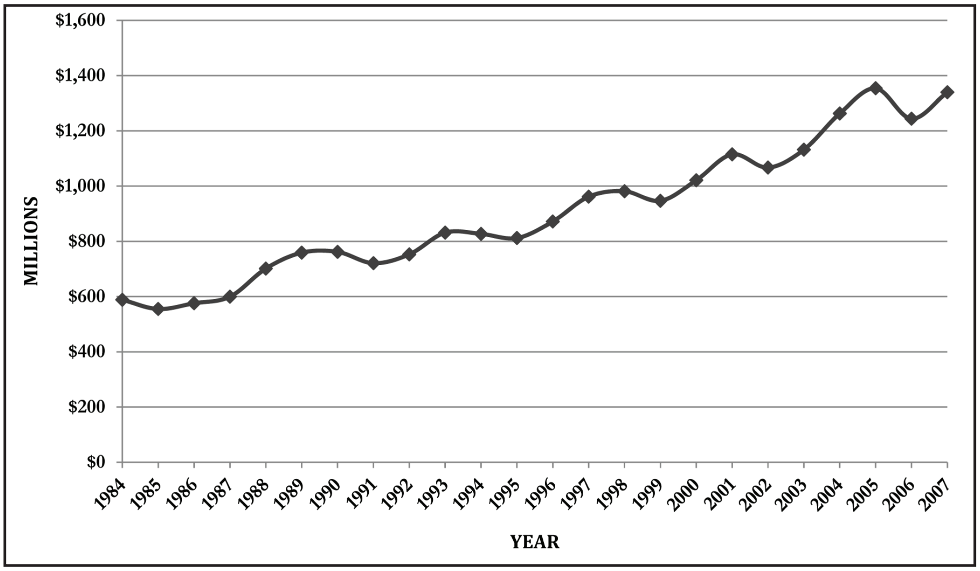


Figure 8.1.9. Trend in agricultural receipts in Utah (1984-2007). Source: Utah Agricultural Statistics (1984-2008).

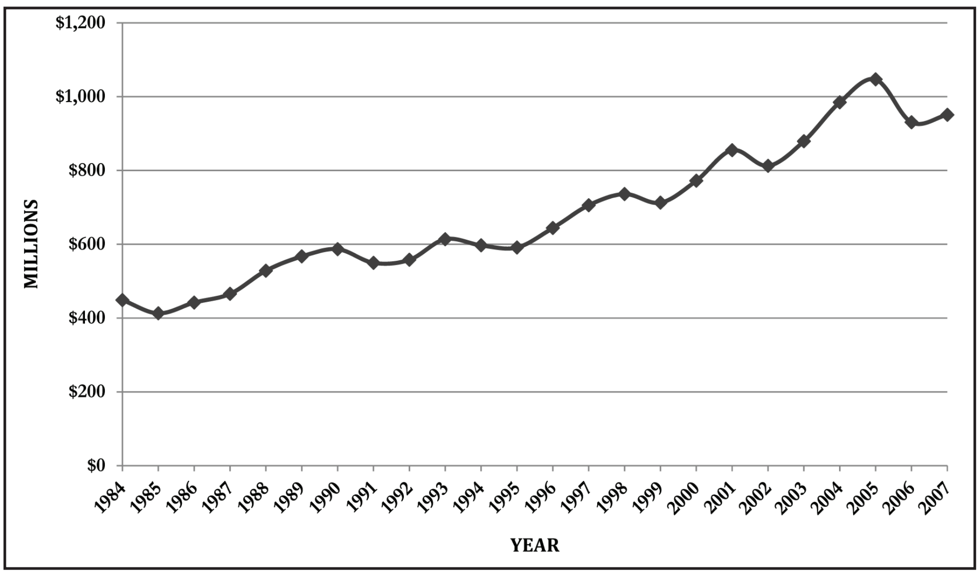


Figure 8.1.10. Trend in livestock and livestock product receipts in Utah (1984-2007). Source: Utah Agricultural Statistics (1984-2008).

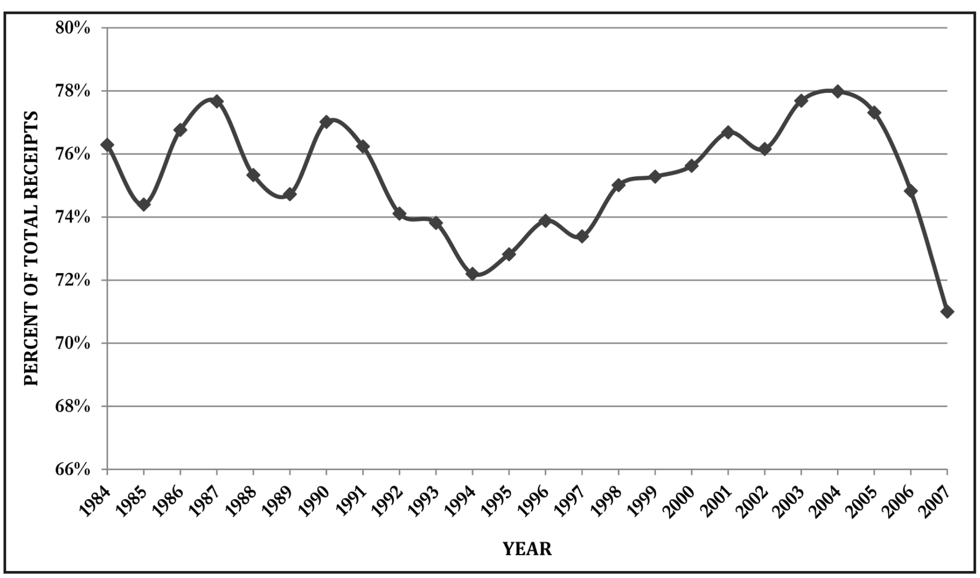


Figure 8.1.11. Livestock and livestock product receipts as a percentage of Utah agricultural receipts (1984-2007). Source: Utah Agricultural Statistics (1984-2008).

FIRE IN UTAH

Ellie I. Leydsman McGinty
Christopher M. McGinty

Prior to Euro-American settlement in the mid-1800s, fire played an important role in the health and evolution of ecosystems by recycling nutrients, improving soil productivity, and by maintaining biodiversity, community composition, habitat structure, and watershed condition (DiTomaso, 2000; Griffin, 2002; Allen, 2002; Dombeck et al., 2004; Miller and Heyerdahl, 2008). While the value of fire in ecosystems has only been realized in the recent past, aboriginal Americans noted and made use of fire throughout their time in the region (Griffin, 2002; Allen, 2002). Historic accounts show that fire was used in localized areas to increase the availability of desirable plants, as a hunting strategy, and to remove available forage in the event that enemies attempted to cross tribal lands (Downs, 1966; Allen, 2002; Parker, 2002; Griffin, 2002). Accounts by friars Domínguez and Escalante, on their exploration into what would become the Utah Territory, reported intentional burning by local Paiute Indians to dissuade the party of explorers that was mistaken for a group of invading Comanche Indians (Griffin, 2002).

Intentional burning by Native Americans in the western United States caused few changes to the overall vegetation communities when contrasted to larger, naturally occurring fires ignited by lightning (Parker, 2002). The use of fire by native populations, even over relatively small geographic areas for cultural purposes, was vilified by Spanish explorers and Euro-American settlers moving into the region (Downs, 1966; Griffin, 2002). The practice of utilizing fire to improve the environment was eventually referred to as Paiute forestry by settlers and deemed punishable by early Western laws (Wuerthner, 2006).

Consequently, fire suppression policies were heavily enforced, resulting in modifications to fire behavior. The frequency, intensity, severity, and seasonality of fires changed (Bock et al., 1993; Davison, 1996). Simultaneously, these alterations increased the complexity and cost of fire suppression, forcing the government to bring administrative tasks under the jurisdiction of federal organizations, such as the United States Forest Service and the Bureau of Land Management. These organizations were tasked with the responsibility of fighting and suppressing wildland fires across the United States. Presently, these agencies are supported by billions of dollars, fleets of ground and aircraft equipment, and an army of manpower (Wuerthner, 2006). The financial burden of fire fighting and suppression has subsequently been incurred by United States taxpayers (Wuerthner, 2006).

Due to the alteration of natural fire regimes, significant changes to the vegetation structure, vegetation type, and the natural fire return intervals have occurred. Major ecosystems, including grasslands, sagebrush, sagebrush steppe, and upland forested regions have experienced some of the greatest alterations due to fire suppression policies. The Federal Wildfire Occurrence Dataset indicates that Utah was subject to nearly 24,000 fires between 1980 and 2007 (Figure 8.2.1). To date, 2007 was the largest fire year on record with more than 1,400 fires burning 620,730 acres. The 2007 season saw the largest recorded fire in Utah's history, the Milford Flat Fire, burning 363,052 acres of land near Milford, Utah (NICC, 2007). The increased frequency and intensity of fires has had a significant impact on the ecosystems of Utah.

EFFECTS OF FIRE ON GRASSLAND ECOSYSTEMS

The desert and mountain grassland ecosystems of Utah have been exposed to the effects of altered fire return intervals since settlement by Euro-Americans. Prior to widespread settlement, fire ignition was generally caused by lightning and only occasionally by aboriginal peoples (Rice et al., 2008; Griffin, 2002; Parker, 2002). Pre-settlement fire return intervals in desert grassland systems are debatable, but thought to have ranged from 35 to more than 300 years, and the higher, more mesic mountain grassland systems ranged from 10 to 110 years (Figure 8.2.2). This broad variation in return interval is due to changes in available seasonal precipitation and temperature (UDFFSL, 2007; Rice et al., 2008). Introduction of non-native species and open grazing practices during the late-1800s and through the 1900s in these ecosystems increased flammable fuel loads, enhanced fire susceptibility, decreased biodiversity, and shortened the fire return intervals (Rice et al., 2008). In addition to these changes, and because the system did not evolve with regular fire, plants in the desert and mountain systems have not adapted to repeated burning and have largely decreased in overall health and abundance (UDFFSL, 2007).

As settlements expanded in desert grassland areas, non-native species were planted to stabilize soils and improve depleted forage in overgrazed areas (Rice et al., 2008). In the late-1800s, species, such as red brome, were inadvertently introduced and began rapidly invading the already invasive-prone systems. Woody plants that occurred in desert grassland systems were found to be highly susceptible to

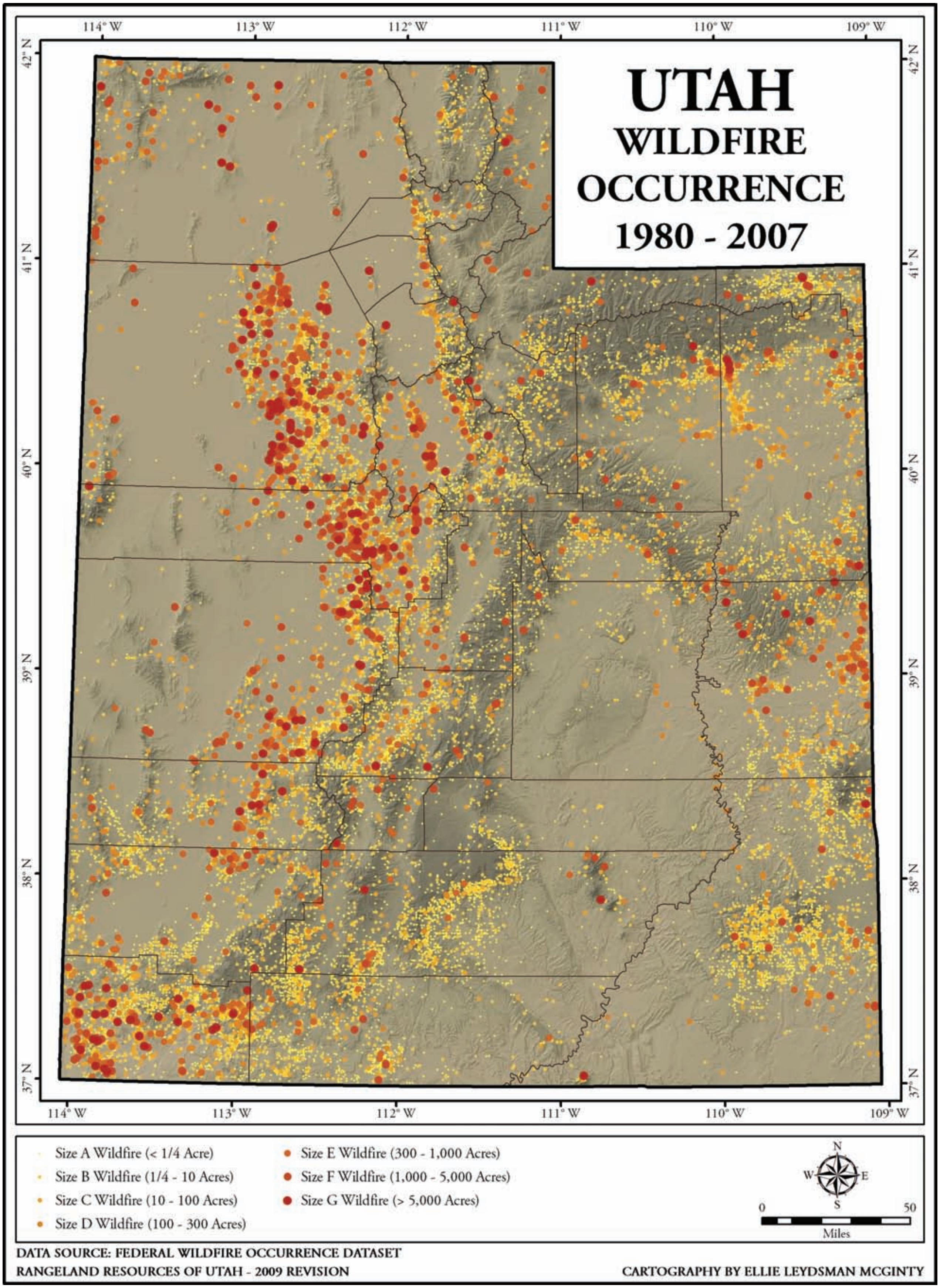


Figure 8.2.1. Wildfire occurrence in Utah from 1980 to 2007.

fire and the slow-growing species would rarely re-sprout once burned. Further, many of the slow-sprouting woody plants could take up to 10 years to begin producing seed, thus reducing the probability of site recovery from burning and intense grazing (Rice et al., 2008).

Mountain grasslands in the region are less susceptible to fire than those of the xeric desert lowlands; however, dry years bring an elevated risk of fire to the system. These regions have historically offered plentiful livestock forage in wet years and adequate forage even in drier years. Because these native systems often maintained dense stands of native grasses, advancement of non-native species due to fire has been slower than those systems in desert environments. Invasive species such as cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caput-medusae*) have made inroads into these communities, affecting native plant populations, livestock, and wildlife forage (Rice et al., 2008).

EFFECTS OF FIRE ON SAGEBRUSH AND SHRUBSTEPPE ECOSYSTEMS

Fire is a natural and essential component in native sagebrush steppe and semi-desert shrubland ecosystems. The frequency of fires in native vegetation communities is variable and depends on sagebrush, shrub, or woodland species, geographic location, climatic variables, and soil properties. In many semi-desert shrubland communities, the structure, characteristics, and lack of a continuous fuel source do not readily promote the spread of fire; therefore, the fire return interval typically ranges from 60 to 110 years (Pimental et al., 2005). Sagebrush steppe and mountain brush plant communities occurring at higher elevations and latitudes in the Great Basin desert have a shorter mean fire return interval of 30 to 100 years because the shrub cover is denser and the shrub architecture is more flammable (Brooks and Pyke, 2001). Native communities of mountain big sagebrush have a mean fire return interval of 12 to 25 years (Miller and Tausch, 2001) (Figure 8.2.2).

In many sagebrush steppe and semi-desert shrubland ecosystems, the behavior and characteristics of fire have been modified as a result of fuel reductions by livestock grazing and human-induced fire suppression (Brooks and Pyke, 2001). Large concentrations of livestock have significantly reduced the cover of native grasses and forbs, and consequently facilitated the establishment of invasive plant species. Invasive plants, such as cheatgrass, have increased the fire return interval and inhibited the germination and propagation of native annuals and perennials (Pimentel et al., 2005). Cheatgrass provides a dense and continuous fuel source that extends the seasonality and increases the frequency of fires (USGS, 2002). Consequently, it often converts arid low-elevation sagebrush-bunchgrass communities into annual-dominated grasslands (Davison, 1996). The change in natural fire regime and conversion to non-native annual grasses has had inadvertent impacts on wildlife species (USGS, 2002).

Historic grazing practices and fire suppression has also encouraged the expansion of woodlands into areas previously occupied by sagebrush and semi-desert shrubs. Historically, fire played an integral role in maintaining sagebrush-steppe communities by limiting conifer encroachment, but the rapid increase in domestic livestock and reductions in fire frequency created ideal conditions for the establishment of woodland seedlings, such as juniper and pinyon pine (Bock et al., 1993; Madany and West, 1983). Woodland species began increasing into low and mountain big sagebrush communities during the late-1800s when grazing by livestock reduced the fine fuels required for low-intensity fires and decreased the competition provided by native herbaceous species (Miller and Rose, 1999). The extent of mountain big sagebrush has been significantly reduced by recent woodland expansion because the fire return interval has increased to greater than 100 years in some regions (Miller and Tausch, 2001).

EFFECTS OF FIRE ON UPLAND FOREST ECOSYSTEMS

Historically, fire influenced the structure, composition, and dynamics of semiarid western, interior forests (Zimmerman and Neuenschwander, 1984; Belsky and Blumenthal, 1997). Western forest tree densities, particularly in juniper woodlands and ponderosa pine forests, were maintained by two natural phenomena: low-intensity surface fires and competitive exclusion of tree saplings by dense understory grasses (Belsky and Blumenthal, 1997). Modifications in western forest ecology have occurred as a result of post-settlement land-use change and management, heavy grazing by sheep and cattle, reduced return intervals for low-intensity ground fires that served to thin dense stands of younger trees, and favorable climate years for tree reproduction around the turn of the nineteenth century (Borman, 2005; Belsky and Blumenthal, 1997; Miller and Tausch, 2001).

Juniper and pinyon-juniper woodlands have experienced pronounced change in both the distribution and density across the Intermountain West. Prior to Euro-American settlement, juniper and pinyon pine species were primarily

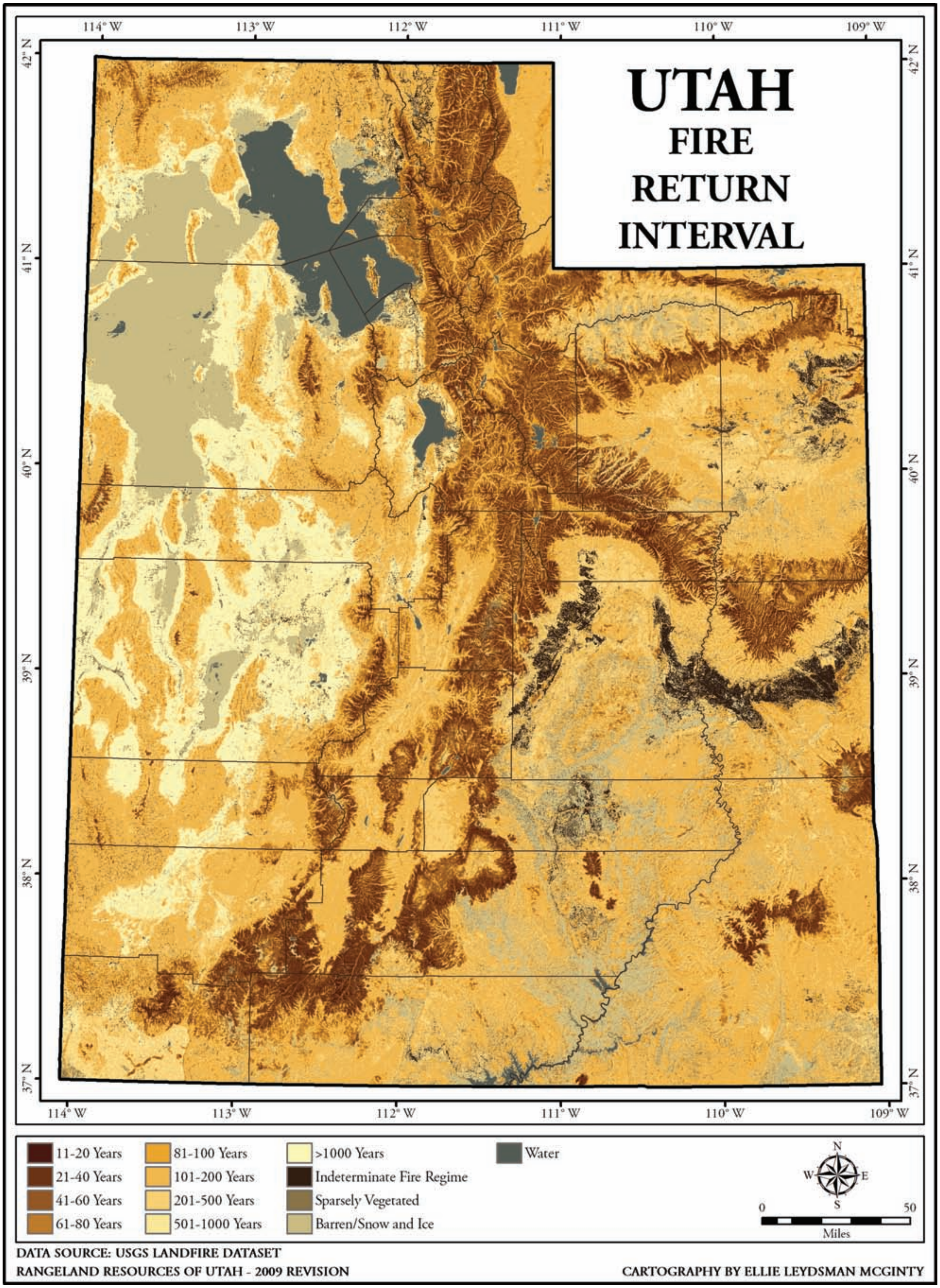


Figure 8.2.2. USGS LANDFIRE fire return intervals in Utah derived from vegetation and disturbance dynamics.

confined to rocky ridges or surfaces where sparse vegetation limited fire. Woodlands were characteristically open, sparse, and savanna-like from frequent low-intensity fires (Miller et al., 1995; Madany and West, 1983). However, juniper and pinyon-juniper woodlands throughout the Great Basin began to expand during the late 1800s and early 1900s. The expansion coincides with the introduction and increase of livestock, and the subsequent reduction in herbaceous species that served as fine fuel loads. Additionally, between 1850 and 1916, winters became milder and precipitation was greater than the long-term average. The wetter, milder conditions promoted vigorous growth in conifers (Miller and Rose, 1999; Miller and Tausch, 2001). The expansion of juniper and pinyon-juniper woodlands has been most dramatic in areas with deeper, well-drained soils; consequently, sagebrush steppe, semi-desert shrubland, grassland, aspen, and riparian plant communities are being invaded and displaced (Miller et al., 1995; Miller and Tausch, 2001).

In Rocky Mountain forests, the most extensive and heavily impacted communities have been those dominated by ponderosa pine and aspen. Historically, ponderosa pine forests were characterized by open stands of trees with a lush, herbaceous understory of perennials and varying densities of shrubs. Frequent, non-catastrophic fire was an important determinant in maintaining plant community structure and composition, particularly in dry southwestern ponderosa pine forests (Bock et al., 1993; Schoennagel et al., 2004). The historic mean fire return interval of ponderosa pine forests varied from 4 to 36 years (Schoennagel et al., 2004); however, research indicates that mean fire return interval in intermediate- and high-elevation ponderosa pine forests was longer, ranging from 30 to greater than 40 years (NPS, n.d.) (Figure 8.2.2). Aspen, a disturbance-dependent species, has also declined over much of its former range due to fire suppression and conifer encroachment (Bartos and Campbell, 1998).

Although higher-elevation ponderosa pine forests typically have longer fire return intervals and higher intensity fires than ponderosa pine forests in the southwest (NPS, n.d.), livestock grazing and fire suppression policies have promoted widespread stands of dense fire-sensitive and disease-susceptible trees (Belsky and Blumenthal, 1997). Intensive grazing by sheep and cattle was the primary agent in reducing the herbaceous vegetation and modifying vegetation structure (Madany and West, 1983; Touchan et al., 1995). The shift in vegetation structure encouraged the proliferation of trees, reduced flammability, and decreased fire frequency (Madany and West, 1983). Extensive fire prevention efforts from 1930 through 1960 intensified the effects (Borman, 2005). Presently, the dense stands of trees can provide fuels at intermediate heights that can carry fire up into continuous canopy fuels, thus increasing the probability of large, catastrophic, and stand-replacing fires (Schoennagel et al., 2004; Baker and Ehle, 2001).

FIRE AS A MANAGEMENT STRATEGY

Fire suppression efforts have interrupted the natural fire cycle in many intermountain rangeland environments (Weber et al., 2001). The frequency, intensity, severity, and seasonality of fire have been altered. Vegetation and wildlife communities have been modified; rangeland productivity has decreased; fuel loads have reached unprecedented levels; fire-tolerant, non-native plants have proliferated; and catastrophic fires have become common (Bock et al., 1993; Davison, 1996; Weber et al., 2001). Consequently, federal and state agencies are beginning to focus on management strategies that reduce fuel build-up and the risk of fire. One of the primary methods being implemented and evaluated is prescribed burning.

Prescribed burning is the controlled application of fire to wildland fuels to attain planned resource management goals (Johnson, 1984). Research conducted in the Rocky Mountains confirmed the widespread use of fire by native people to manipulate and improve vegetation communities (Kay, 2007). When prescribed burning policies are founded on ecological principles, prescribed burning can reduce wildfire risk and severity, control invasive plants, suppress woody species, improve forage and rangeland productivity, and enhance wildlife habitat and native plant communities (Brooks and Pyke, 2001; DiTomaso, 2000; Dombeck et al., 2004; Madany and West, 1983; Yoder et al., 2003). Prescribed burning can mitigate fire severity through the reduction of tree and shrub density and accumulated fuels (Pollet and Omi, 2002; Madany and West, 1983).

Prescribed burning is an ecologically sound way to improve wildlife habitat. Land management plans that integrate prescribed burning can enhance the habitat of game species and plants and/or animals of concern. It can open areas for increased movement, reduce ground litter, control brush encroachment, increase nutritional value, and diversify plant species (Anderson and McCuistion, 2008). Fire removes litter and dead standing herbage of low nutritional value and increases forage production. Consequently, herbivores can more efficiently select nutritious plant material (Bleich et al., 2005, Madany and West, 1983; Anderson and McCuistion, 2008).

Prescribed burning can be used to control invasive plants. However, the decision to use fire as a management tool must evaluate interrelationships between fire and invasive plants because fire may promote rapid recovery of invasive species and/or the establishment of other fire-tolerant invasive plants (Brooks and Pyke, 2001; DiTomaso, 2000). Information on the physiology, anatomy, life history, and seed dispersal and longevity of invasive plants is integral to the decision (Brooks and Pyke, 2001). The timing of prescribed burning is critical for success. In general, prescribed burns should be conducted following seed dispersal by invasive plants and senescence of native grasses and forbs (DiTomaso, 2000). December is the preferred month to avoid damage to native forbs in sagebrush steppe environments (Anderson and McCuistion, 2008). Additionally, rehabilitation work, such as seeding with mixes of native species, is often required after prescribed burns (Beck and Mitchell, 2000). Immediate revegetation with desirable and competitive plant species is a sustainable long-term method for suppressing invasive plants, while providing high forage production on rangeland (DiTomaso, 2000).

Although prescribed burning is gaining favor in many areas, it has some drawbacks. Prescribed burning is an inherently risky resource management tool because there is a threat that the fire may escape and spread, people may be injured, and equipment may be lost. Therefore, prescribed burning can impose unintended costs (Yoder et al., 2003; Johnson, 1984). Also, the smoke and pollution produced by prescribed burns may violate regulations, such as the Clean Air Act, and may impact surrounding communities (Davison, 1996). Because of air quality concerns and the need for correct fire-weather conditions, there is usually a narrow period of time in which prescribed burning can be conducted (Nader et al., 2007).

INVASIVE PLANTS IN UTAH

Ellie I. Leydsman McGinty
Christopher M. McGinty

An increasing threat to rangeland biodiversity and health is the invasion by non-native plant species (Frost and Launchbaugh, 2003; SRM, n.d.). Some of the most prevalent and problematic invasive plants include diffuse knapweed (*Centaurea diffusa*), spotted knapweed (*Centaurea maculosa*), yellow starthistle (*Centaurea solstitialis*), leafy spurge (*Euphorbia esula*), and cheatgrass (*Bromus tectorum*) (DiTomaso, 2000). The vast majority of invasive plants have been introduced from other continents. Cheatgrass, the most widespread and dominant invasive plant in the Intermountain West, was introduced during the mid- to late-1800s by means of imported grain from Eurasia (DiTomaso, 2000; Knapp, 1996). The first records of cheatgrass in the Great Basin came from Provo, Utah, in 1894; Elko, Nevada, in 1905; and Reno, Nevada, in 1906 (Knapp, 1996).

The dispersion of non-native plants was originally linked to direct human activity, particularly along railroad lines (Knapp, 1996). However, decades of grazing in the Intermountain West during the open range era, and poor grazing management practices facilitated the invasion, establishment, and spread of non-native plant species (Frost and Launchbaugh, 2003; Vavra et al., 2007). Prior to the introduction of non-native plants, Intermountain rangelands were predominantly characterized by perennial bunchgrasses, forbs, and shrubs (Hull and Hull, 1974). As the livestock industry expanded and human populations began to flourish, the proportion of non-native plant species began to increase. Many native plant communities became destabilized and the spread of non-native plants was encouraged. The process of destabilization was intensified because many native perennial grasses lack high seedling vigor and some do not readily recover from grazing (DiTomaso, 2000). In contrast, invasive winter annual grasses, such as cheatgrass and medusahead (*Taeniatherum caput-medusae*), have high seedling vigor, and they outcompete native plants by exploiting valuable resources and completing their life cycle prior to the summer dry period (Frost and Launchbaugh, 2003). The reduced competition from native plants perpetually favors the spread of invasive plants because many are unpalatable, aversive, or toxic to livestock (DiTomaso, 2000).

Livestock and human activity can also promote the spread of non-native plants through ground disturbance and the physical dissemination of seeds. Disturbance appears to be an important aspect in the establishment of non-native plant populations because many invasive plants are adapted to soil disturbance, such as that caused from trampling or off-road vehicle use (Vavra et al., 2007). Invasive plant seeds, such as cheatgrass and houndstongue, are dispersed by adhering to the coats of animals, while others are dispersed as they pass through digestive tracts (Frost and Launchbaugh, 2003; Fleischner, 1994).

EFFECTS OF INVASIVE PLANTS

Invasive plants can have a significant impact on an array of ecological facets. Invasive plants have reduced species richness, plant diversity, and community productivity. Wildlife habitat and forage have been degraded; soil erosion and stream sedimentation have increased; soil moisture and nutrient levels have been depleted; and fire regimes have been altered (Frost and Launchbaugh, 2003; Wallace et al., 2008). As cheatgrass has become a common component of sagebrush steppe vegetation communities, the nutritional quality of forage has been reduced, the intensity and frequency of fires have changed, and water cycles have been altered. Although many factors are involved, several native animals, such as sage grouse, may have declined as a result of these changes (SRM, n.d.).

Invasive broadleaf species that have deep taproot systems, such as yellow starthistle, have modified surface runoff, stream sediment yields, soil moisture, and soil nutrients (DiTomaso, 2000). Yellow starthistle can extract soil moisture from the entire soil profile and outcompete native shallow- and deep-rooted annual and perennial species (Wallace et al., 2008). Woody plant species, such as saltcedar (*Tamarix* spp.), have invaded wetland and riparian systems throughout the western United States. Dense populations of saltcedar lower water tables, reduce the volume of surface water, alter flood frequency, increase soil salinity, and reduce the diversity and productivity of the herbaceous understory (Masters and Sheley, 2001; DeLoach et al., 2000). These changes combined suggest that invasive plants can significantly alter ecosystem processes, cause ecosystem instability, displace native plant species that are vital to wildlife and livestock, and reduce the capacity for ecosystems to provide the services required by society (Knapp, 1996; Masters and Sheley, 2001).

The invasion of non-native plant species not only produces various ecological modifications, but also results in substantial socioeconomic impacts, particularly to the livestock industry and land management agencies responsible for fire suppression. Invasive plant species cause more economic loss on rangeland than all other pests combined.

Invasive plants reduce the carrying capacity for livestock by lowering the forage yield. Consequently, the costs of managing and producing livestock increase (DiTomaso, 2000).

Research has demonstrated that leafy spurge and knapweed species can reduce grazing capacity by more than half. However, some rangelands have deteriorated to the point that desirable species are either not present or in such low abundances that plant community recovery is slow or will not occur without revegetation efforts (Masters and Sheley, 2001). Although cheatgrass is used to some degree as livestock forage, in some years it only provides 10 percent of the productivity of the perennial species it replaced. Cheatgrass can be a nutritious and palatable forage crop during the growing season, but it is often an unreliable source because of its dependency on annual precipitation, and awned cheatgrass can pose severe health problems to livestock after it has matured (Knapp, 1996).

Invasive plant species, specifically cheatgrass, have altered the fire regimes of many environments in the western United States, and consequently imposed an economic burden on management agencies faced with fire suppression. Prior to the invasion of cheatgrass in sagebrush steppe ecosystems, the fire return interval was approximately 60 to 110 years; however, cheatgrass has changed the fire frequency to 3 to 5 years (Pimentel et al., 2005). Cheatgrass fires are common because the amount of fine fuel that accumulates is greater than what occurs in sagebrush-bunchgrass communities (Knapp, 2005). The increased fire frequency does not permit establishment by native annuals and perennials, and therefore, native plants are diminishing and monocultures of cheatgrass are dominating (Knapp, 2005; Pimentel et al., 2005). The cost of wildfire suppression on public land is rising with the federal fire bureaucracy spending hundreds of millions of dollars annually on resource losses, suppression costs, presuppression costs, fire management, and rehabilitation programs (Dombeck et al., 2004; Knapp, 1996).

MANAGEMENT STRATEGIES

Attempts to manage and eradicate invasive plant species have been made utilizing various control methods. Historically, mechanical and chemical control techniques were the predominant invasive plant management methods; however, biological and cultural control techniques have been implemented and integrated with other practices. Mechanical control techniques include hand-pulling, hoeing, mowing, tilling, chaining, and bulldozing. Hand-pulling and hoeing are effective in controlling small infestations of shallow-rooted weeds in loose, moist soils (DiTomaso, 2000). Mowing is commonly used to control invasive range annuals and some perennials; however, the success of mowing is highly dependent on timing. Annuals and some perennials can be suppressed and controlled if mowing occurs before viable seeds form. If not properly timed, mowing can promote the spread of invasive plants by encouraging the spread of seeds and stimulating the production of new stems from vegetative buds (DiTomaso, 2000; Masters and Sheley, 2001). Tilling practices can control annual species, but they rarely provide control of perennial species. In fact, perennial or biennial species, such as spotted knapweed and perennial pepperweed, often spread as a result of tilling (DiTomaso, 2000). More expensive mechanical control techniques, such as chaining and bulldozing, are effective in controlling invasive shrub and tree species. Although these methods require gentler terrain and are becoming increasingly expensive, they are effective in controlling shrubs and trees that do not readily resprout from root systems (DiTomaso, 2000; Masters and Sheley, 2001).

Chemical control techniques include the application of herbicides, such as 2,4-D, glyphosate, picloram, and teburthiuron. Herbicides are the primary method of invasive plant control in most rangeland systems (DiTomaso, 2000; Masters and Sheley, 2001). However, most herbicides do not provide adequate control without several successive annual applications (Knipe, 1983), and they seldom provide long-term control (DiTomaso, 2000). Timing of herbicide application is also essential to effective control because it is highly dependent on the species and the herbicide being applied. Additionally, herbicides that are effective in controlling invasive plants are often toxic to native herbaceous plants and have the potential to contaminate surface and ground water (DiTomaso, 2000; Masters and Sheley, 2001).

Biological control includes the planned use of living organisms to reduce the reproductive capacity, density, and effect of invasive plant species (Masters and Sheley, 2001). The primary goal of biological control techniques is to exert environmental stress on invasive plants by reestablishing interactions with natural enemies (DiTomaso, 2000; Masters and Sheley, 2001). Although there have been many attempts to control invasive plants on rangelands, the success has been variable and limited. Biological control has been moderately effective in controlling leafy spurge and saltcedar. For example, recent research indicates that the use of an Asian leaf beetle (*Diorhabda elongata deserticola*) has been successful in controlling up to 85 percent of saltcedar populations in research sites in Grand County, Utah (Johnson and Higgs, 2007; Lewis et al., 2003). Important factors that have contributed to the limited success of biological control are often attributed to a high level of genetic diversity in the target species (Masters and Sheley, 2001).

Cultural control techniques include prescribed burning, reseeding or revegetation efforts, the modification of grazing management plans, and the implementation of prescription or targeted grazing (Masters and Sheley, 2001). Prescribed burning is often used for long-term suppression of woody species in sagebrush and juniper ecosystems and it can stimulate native annual and perennial grass growth (DiTomaso, 2000). Seeding and other revegetation efforts are often alternatives for managing invasive plants in areas that lack desirable species. Revegetation with competitive grasses and forbs may suppress non-native plants, enhance plant community resistance to further invasion, and improve forage production and quality (Masters and Sheley, 2001).

Recent cultural control techniques have focused on the modification of grazing management plans and the implementation of prescription grazing. Properly managed livestock can minimize the spread of invasive plants on rangelands (Wallace et al., 2008; DiTomaso, 2000). Moderate grazing levels can minimize the impact to native plants, whereas intensive grazing can counteract the dietary preferences of cattle, resulting in equal impacts to all forage species including invasive plants. Grazing by multiple species, such as sheep, cattle, and goats, can distribute the impact of livestock more uniformly among desirable and undesirable species. Adjusting the timing of grazing to coincide with the susceptible life-cycle phases of invasive plants can also have substantial control impacts (DiTomaso, 2000).

Targeted or prescription grazing is the application of livestock at a specified season, intensity, and frequency to achieve specific vegetation management goals, such as the control of invasive plants (Wallace et al., 2008). Successful prescription grazing should cause significant damage to the target plant, limit damage to native vegetation, be consistent with livestock production goals, and be integrated with other control methods. Prescription grazing also entails the modification of livestock grazing behavior (Frost and Launchbaugh, 2003). The species of livestock suited for control of invasive plants depends on the species of concern and the production setting. Research has evaluated the effectiveness of cattle, sheep, and goats in targeted grazing. Although cattle can manage fibrous herbaceous vegetation, they appear to offer the least potential for control of invasive plants. Sheep are considered an excellent species to accomplish control of herbaceous plants, such as leafy spurge, due to their ability to tolerate substantial fiber content (Frost and Launchbaugh, 2003). Goats are the most well-known domestic grazer that function as plant control agents (Brock, 1988). Goats are classified as browsers, and their physical characteristics allow them to select individual leaves or chew entire branches. Although they can be very selective herbivores, goats are reputed to utilize a wider range of vegetation than other livestock species (Knipe, 1983). They also have a large liver mass relative to cattle or sheep, and can therefore process plants that contain secondary chemical compounds, such as tannins or terpenes (Frost and Launchbaugh, 2003).

INTEGRATED MANAGEMENT STRATEGIES

The implementation of one control method is rarely effective in achieving the desired results for curtailing the spread of invasive plants. Successful long-term and cost-effective management programs should integrate a variety of mechanical, chemical, biological, and cultural control techniques (DiTomaso, 2000). Integrated management involves the deliberate selection, combination, and implementation of effective invasive plant management strategies with due consideration of economic, ecological, and sociological consequences (Sheley et al., 2004).

Although integrated management emerged as a viable concept in the 1970s, the practice has not been systematically implemented until recently because effective integrated management plans and programs require a thorough understanding of the ecology and biology of invasive plants and invaded plant communities (Masters and Sheley, 2001). Presently, there are several examples of integrated strategies used to manage invasive plants and improve rangeland communities. Much attention has been focused on the integration of targeted or prescription grazing with other control methods, as the incorporation of grazing management is an essential component in successfully addressing invasive plant problems (Frost and Launchbaugh, 2003).

WILDLIFE IN UTAH

Ben D. Baldwin
Roger E. Banner

Utah has a wide variety of diverse habitats created by a complex mix of geology, climate, elevation, and precipitation. These habitats support more than 700 species of vertebrate wildlife. Wildlife populations and habitat face a variety of natural and man-made threats, including changes to land-management practices, fragmentation, introduction of non-native plant and animal species, and urban development. These threats have resulted in an increased emphasis on conservation and management over the past two decades, especially for species of special concern.

Increased emphasis on conservation and management has resulted in greater focus on the determination of sustainable habitat and estimations of available habitat acreage for wildlife focused on big game species. Information concerning wildlife populations is difficult to obtain, and long-term trends are often unreliable due to changes in sampling and estimation protocol and lack of data. Most wildlife information focuses on hunted and big game species with emphasis on animals taken or hunter success rather than total population estimates. Changes in administrative boundaries, both at the state and federal level, further exacerbate calculating wildlife population trends over time.

PRIVATE LANDS

Private lands make up 21.1 percent of the land area in Utah. They provide approximately 24 percent of the total mule deer habitat, 23 percent of the elk habitat, 19 percent of the pronghorn antelope habitat, 3 percent of the bighorn sheep habitat, 34 percent of the moose habitat, and 4 percent of the bison habitat in the state (Table 8.4.1).

Within private lands, Cooperative Wildlife Management Units (CWMUs) provide additional important habitat (Figure 8.4.1). CWMUs, formerly known as Posted Hunting Units, are areas consisting mostly of private lands that are authorized by the Utah Division of Wildlife Resources (UDWR) for the specific purpose of managing for wildlife habitat. There are more than 100 identified CWMUs with a total area of over 2 million acres in Utah, located in 23 counties (Sutter et al., 2005).

STATE LANDS

State lands include state trust lands, state sovereign lands, state parks, and state wildlife management areas. Altogether, they consist of 10 percent of the land area in Utah. They provide 7 percent of the mule deer habitat, 8 percent of the elk habitat, 10 percent of the pronghorn antelope habitat, 8 percent of the bighorn sheep habitat, 5 percent of the moose habitat, and 18 percent of the bison habitat (Table 8.4.1).

TRIBAL LANDS

Native American tribal lands comprise 4.5 percent of the land area in Utah. These lands provide approximately 3 percent of the mule deer habitat, 5 percent of the elk habitat, 2 percent of the pronghorn antelope habitat, 6 percent of the bighorn sheep habitat, 2 percent of the moose habitat, and 24 percent of the bison habitat (Table 8.4.1).

FEDERAL LANDS

Federally administered lands include 64.3 percent of the land area in Utah and provide the majority of habitat for wildlife species in Utah. These lands provide 65 percent of the mule deer habitat, 65 percent of the elk habitat, 69 percent of the pronghorn antelope habitat, 84 percent of the bighorn sheep habitat, 60 percent of the moose habitat, and 54 percent of the bison habitat (Table 8.4.1).

Bureau of Land Management (BLM) – BLM lands comprise 42 percent of the land area in Utah. These lands provide 35 percent of the mule deer habitat, 26 percent of the elk habitat, 63 percent of the pronghorn antelope habitat, 54 percent of the bighorn sheep habitat, 5 percent of the moose habitat, and 54 percent of the bison habitat (Table 8.4.1).

Big game populations on BLM-managed lands have had significant increases since 1940 (Table 8.4.3). All species have grown in numbers since early population estimates with elk and bighorn sheep at historic highs.

United States Forest Service (USFS) – Forest Service lands make up 15 percent of the land area in Utah. These lands provide important habitat for higher elevation species, such as moose and elk. Approximately 28 percent of the mule deer habitat, 38 percent of the elk habitat, 3 percent of the pronghorn antelope habitat, 11 percent of the bighorn sheep habitat, and 55 percent of the moose habitat occur on Forest Service-administered lands. No bison habitat occurs on Forest Service lands (Table 8.4.1).

Table 8.4.1. Big game habitat on Utah lands.

BIG GAME SPECIES	HABITAT TOTAL	BLM	USFS	OTHER FEDERAL	STATE	PRIVATE	TRIBAL
MULE DEER							
AREA (ACRES)	28,577,212	10,072,002	8,031,771	538,286	2,030,408	6,961,435	943,311
HABITAT (PERCENT)	100	35.2	28.1	1.9	7.1	24.4	3.3
ROCKY MOUNTAIN ELK							
AREA (ACRES)	18,354,422	4,835,092	6,939,450	108,943	1,404,781	4,182,754	883,401
HABITAT (PERCENT)	100	26.0	38.0	1.0	8.0	23.0	5.0
PRONGHORN ANTELOPE							
AREA (ACRES)	12,438,548	7,826,312	354,304	417,090	1,292,270	2,367,390	181,181
HABITAT (PERCENT)	100	62.9	2.9	3.4	10.4	19.0	1.5
BIGHORN SHEEP							
AREA (ACRES)	7,362,297	3,939,720	798,694	1,422,120	577,695	212,963	411,108
HABITAT (PERCENT)	100	53.5	10.9	19.3	7.8	2.9	5.6
SHIRAS MOOSE							
AREA (ACRES)	7,328,830	330,969	4,041,450	296	377,161	2,451,988	126,966
HABITAT (PERCENT)	100	4.5	55.1	0.0	5.2	33.5	1.7
BISON							
AREA (ACRES)	1,681,977	906,027	0	7,384	300,012	68,332	400,222
HABITAT (PERCENT)	100	53.9	0.0	0.4	17.8	4.1	23.8

Source: Utah Division of Wildlife Resources GIS data.

Other Federal Lands – Other federal lands include those administered by the National Park Service, the Department of Defense, and the United States Fish and Wildlife Service. These lands consist of 7.3 percent of the land area in Utah, and they provide limited, but important, wildlife habitat. About 2 percent of the mule deer habitat, 1 percent of the elk habitat, 3 percent of the pronghorn antelope habitat, 19 percent of the bighorn sheep habitat, 5 percent of the moose habitat, and less than 1 percent of the bison habitat are provided by other federal lands (Table 8.4.1).

BIG GAME HABITAT TYPES AND POPULATION TRENDS

Mule Deer – Mule deer utilize more habitats within Utah than any other big game species. Approximately 53 percent, or more than 28.6 million acres, of the state have been identified as mule deer habitat (Figure 8.4.5). There has been a decreasing trend in the total amount of mule deer habitat (Table 8.4.4). This habitat has been classified as crucial (84 percent) and substantial (16 percent) (Table 8.4.5). Fifty-four percent of the total habitat has been identified as important fawning area. Mule deer population trends have been downward from around 600,000 animals in 1982 and have varied around 300,000 over the past several decades (Figure 8.4.2). Regardless, they still are the most numerous big game species in the state. Bad winters in the early 1990s and extended drought in the early 2000s resulted in poor fawn production and decreasing populations. The 2009 population estimate was 273,600 (Table 8.4.6).

Rocky Mountain Elk – Rocky Mountain elk, the Utah state mammal, occupies more than 18.3 million acres of habitat, approximately 34 percent of the state (Figure 8.4.6). There has been an increased trend for the total amount of elk habitat (Table 8.4.4). This habitat has been classified as crucial (81 percent) and substantial (19 percent). Seven percent of the total habitat has been identified as important calving area (Table 8.4.5). Elk populations have increased in the past 30 years, from 25,000 in 1982 to a more stable level around 60,000 for the past 13 years (Figure 8.4.3). There were an estimated 67,000 elk in 2009 (Table 8.4.6).

Pronghorn Antelope – Approximately 23 percent of Utah, or more than 12.4 million acres, have been identified as pronghorn antelope habitat (Figure 8.4.7). There has been a decreasing trend for the total amount of pronghorn habitat with a major shift to federal lands (Table 8.4.4). This habitat has been classified as crucial (77 percent) and substantial (23 percent). Fourteen percent of

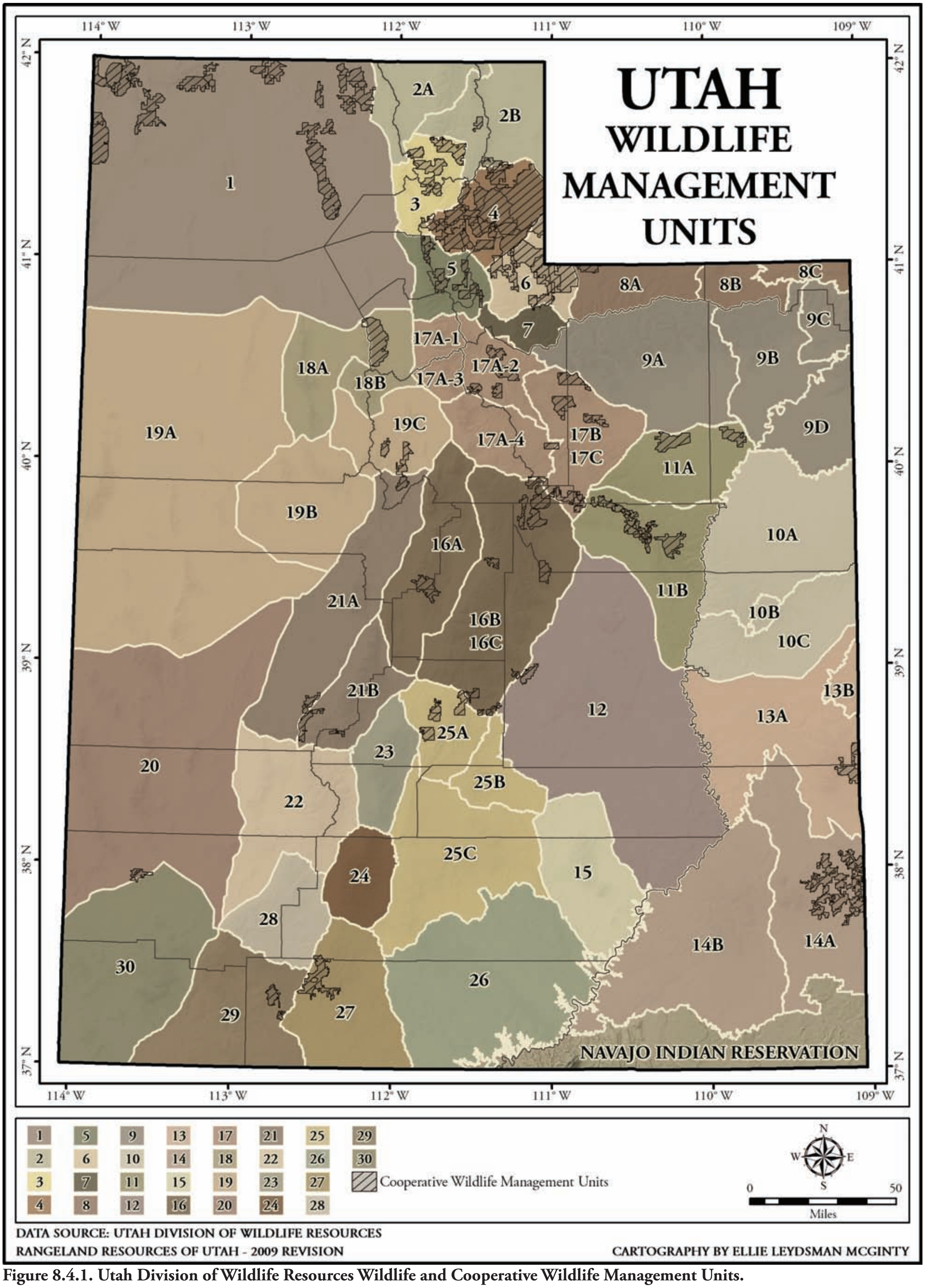


Figure 8.4.1. Utah Division of Wildlife Resources Wildlife and Cooperative Wildlife Management Units.

Table 8.4.2. Utah Division of Wildlife Resources Wildlife Management Units.

UNIT NUMBER	UNIT NAME	UNIT NUMBER	UNIT NAME
1	Box Elder	16A	Central Mountains, Nebo
2A	Cache, North Cache	16B, 16C	Central Mountains, Manti
2B	Cache, South Cache	17A-1	Wasatch Mountains, Salt Lake
3	Ogden	17A-2	Wasatch Mountains, Heber
4	Morgan Rich	17A-3	Wasatch Mountains, Timpanogos
5	East Canyon	17A-4	Wasatch Mountains, Diamond Fork
6	Chalk Creek	17B, 17C	Wasatch Mountains, Currant Creek-Avintaquin
7	Kamas	18A	Oquirrh-Stansbury, North
8A	North Slope, Summit	18B	Oquirrh-Stansbury, South
8B	North Slope, West Daggett	19A	West Desert, Deep Creeks
8B	North Slope, Three Corners	19B	West Desert, Vernon
9A	South Slope, Yellowstone	19C	West Desert, North Tintic
9B	South Slope, Vernal	20	Southwest Desert
9C	South Slope, Diamond Mountain	21A	Fillmore, Oak Creek
9D	South Slope, Bonanza	21B	Fillmore, Pahvant
10A	Book Cliffs, Bitter Creek	22	Beaver
10B	Book Cliffs, Little Creek	23	Monroe
10C	Book Cliffs, South	24	Mt. Dutton
11A	Nine Mile, Anthro	25A	Plateau, Fishlake
11B	Nine Mile, Range Creek	25B	Plateau, Thousand Lakes
12	San Rafael	25C	Plateau, Boulder
13A	La Sal, La Sal Mountains	26	Kaiparowits
13B	La Sal, Dolores Triangle	27	Paunsaugunt
14A	San Juan, Abajo Mountains	28	Panguitch Lake
14B	San Juan, Elk Ridge	29	Zion
15	Henry Mountains	30	Pine Valley

Source: Utah Division of Wildlife Resources GIS data.

Table 8.4.3. Population estimates of big game animals on public lands administered by the Bureau of Land Management in Utah.

YEAR	MULE DEER	ELK	PRONGHORN ANTELOPE	BIGHORN SHEEP	SHIRAS MOOSE	BISON
1940[a]	46,000	425	595	350	NA	NA
1960[b]	277,458	715	1,650	160	NA	65
1965[b]	237,000	680	1,900	310	NA	70
1970[b]	220,000	970	2,120	600	5	120
1975[b]	106,200	1,500	2,675	308	15	160
1980[b]	110,000	2,200	3,500	500	25	200
1985[c]	173,000	10,000	8,400	1,705	225	300
1990[c]	226,000	12,400	10,700	1,100	150	350
1995[c]	188,074	15,725	12,259	2,380	73	493
2000[d]	185,820	27,090	11,335	1,930	77	350
2005[d]	245,650	37,700	9,500	3,500	206	265

Sources: [a]Rangeland Resources of Utah, 1989 (USDI Grazing Service, 1941), [b]Rangeland Resources of Utah, 1989 (USDI Bureau of Land Management, 1961-1981), [c]USDI Bureau of Land Management Facts and Figures (1983 -1996), [d]USDI Bureau of Land Management Public Land Statistics.

Table 8.4.4. Habitat for selected big game species in Utah

BIG GAME SPECIES	UTAH TOTAL		FEDERAL		OTHER	
	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT
MULE DEER						
1967[a]	36,888,000	70	22,880,000	62	14,008,000	38
1980[b]	38,080,000	72				
2008[c]	28,577,212	53	18,642,059	65	9,935,153	35
ROCKY MOUNTAIN ELK						
1967[a]	10,539,000	20	22,880,000	60	4,265,000	40
1980[b]	11,228,000	21				
2008[c]	18,354,422	34	18,642,059	65	6,470,936	36
PRONGHORN ANTELOPE						
1967[a]	21,079,000	40	7,251,000	34	13,828,000	66
1980[b]	5,002,000	10				
2008[c]	12,438,548	23	8,597,707	69	3,840,841	31
BIGHORN SHEEP						
1967[a]	2,635,000	5	594,000	23	2,041,000	77
1980[b]	1,562,000	3				
2008[c]	7,362,297	14	6,160,534	84	1,201,766	16
SHIRAS MOOSE						
1967[a]	527,000	1	398,000	76	129,000	24
1980[b]	5,632,000	11				
2008[c]	7,328,830	13	4,372,715	60	2,956,115	40
BISON						
2008[c]	1,681,977	3	913,411	54	768,566	46

Sources: [a]Rangeland Resources of Utah, 1989 (Colorado State University), [b]Rangeland Resources of Utah, 1989 (United States Forest Service, 1981), [c]Utah Division of Wildlife Resources, 2008.

Table 8.4.5. Habitat type estimations for selected big game species.

BIG GAME SPECIES	HABITAT TOTAL	CRUCIAL HABITAT	SUBSTANTIAL HABITAT	CALVING/FAWNING HABITAT
MULE DEER				
AREA (ACRES)	28,592,790	24,088,570	4,373,937	15,323,187
HABITAT (PERCENT)	100	84.3	15.8	53.6
PERCENT OF UTAH	52.6	44.3	8.3	28.2
ROCKY MOUNTAIN ELK				
AREA (ACRES)	18,361,033	14,897,339	3,463,693	3,996,140
HABITAT (PERCENT)	100	81.1	18.9	7.4
PERCENT OF UTAH	33.8	27.4	6.4	21.8
PRONGHORN ANTELOPE				
AREA (ACRES)	12,444,542	9,637,108	2,807,434	1,752,439
HABITAT (PERCENT)	100	77.4	22.6	14.1
PERCENT OF UTAH	22.9	17.7	5.2	3.2
BIGHORN SHEEP				
AREA (ACRES)	7,364,247	5,314,752	2,049,496	NA
HABITAT (PERCENT)	100	72.2	27.8	NA
PERCENT OF UTAH	13.6	9.8	3.8	NA
SHIRAS MOOSE				
AREA (ACRES)	7,331,375	6,080,221	1,251,154	583,474
HABITAT (PERCENT)	100	17.1	82.9	8.0
PERCENT OF UTAH	13.5	2.3	11.2	1.1
BISON				
AREA (ACRES)	1,682,736	1,655,081	27,655	NA
HABITAT (PERCENT)	100	98.4	1.6	NA
PERCENT OF UTAH	3.2	3.1	0.1	NA

Source: Utah Division of Wildlife Resources GIS data.

Table 8.4.6. Population estimates of selected big game animals in Utah.

BIG GAME SPECIES	1984[a]	1999[b]	2007	2009[f]
MULE DEER	400,000	320,000	305,000[d]	273,600
ROCKY MOUNTAIN ELK	25,000	61,500	63,800[d]	67,000
PRONGHORN ANTELOPE	7,000	12,000	13,700[e]	12,000
BIGHORN SHEEP	2,500	3,445	5,400[e]	5,100
SHIRAS MOOSE	2,000	3,400	4,035[c]	3,700
BISON (HENRY MOUNTAINS)[g]	300	420	463	313

Sources: [a]Rangeland Resources of Utah, 1989 (Grant Jentz, Utah Division of Wildlife Resources, 1984), [b]2000 Internal/External Operational Environmental Assessment Report, UDWR Pub. 00-06, [c]Heather Bernales, Utah Division of Wildlife Resources (2008), [d]Aoude, A. 2007. Antlerless permit recommendations. *Wildlife News*. Utah Division of Wildlife Resources, [e]2008 Utah Division of Wildlife Resources Statewide Management Plans population estimates, [f]Anis Aoude, Utah Division of Wildlife Resources (2009), [g]Bison Unit Management Plan Unit 15 Henry Mountains, Utah Division of Wildlife Resources (2007).

the total habitat has been identified as important fawning area (Table 8.4.5). The population trend for pronghorn has been increasing over the past 20 years, with large emphasis on transplants and releases. The population was estimated at 5,000 in 1982, and it has been approaching 14,000 in recent years (Figure 8.4.4). The 2009 population estimate was 12,000 (Table 8.4.6).

Bighorn Sheep – Utah is home to two subspecies of bighorn sheep: the Rocky Mountain bighorn (*Ovis canadensis canadensis*) and the desert bighorn (*Ovis Canadensis nelsoni*). The California bighorn (*Ovis Canadensis californiana*) is no longer considered to be a subspecies and is now included with the Rocky Mountain subspecies (Figure 8.4.11). Rocky Mountain bighorns are located primarily in the northern half of the state. All of the populations are the result of transplants. The 2009 population estimate for Rocky Mountain bighorns in Utah was approximately 2,400. Desert bighorns are the most abundant subspecies of sheep in Utah, primarily located in southern Utah. The population estimate for desert bighorns in 2009 was 2,700. The overall population trend has been increasing over the past several decades (Figure 8.4.8; Table 8.4.6). The total habitat for all bighorn sheep subspecies combined covers approximately 14 percent of Utah, or more than 7.3 million acres. This habitat has been classified as crucial (72 percent) and substantial (28 percent) (Table 8.4.4). There has been a significantly increasing trend for the total amount of bighorn sheep habitat shifting to federal lands (Table 8.4.6).

Shiras Moose – Shiras moose have limited distribution due to habitat requirements. Within Utah, 14 percent of the state, or more than 7.3 million acres, have been identified as moose habitat (Figure 8.4.12). There has been an increasing trend for the total amount of moose habitat with a large increase in the mid-1980s (Table 8.4.4). This habitat has been identified as important calving area. The general trend for moose populations has been upward since 1982, but varies across management units (Figure 8.4.9). The 2009 population estimate for moose was 3,700 (Table 8.4.6).

Bison – There are now two free-ranging bison herds in Utah managed by the UDWR: the Henry Mountain herd and the recently initiated Book Cliffs herd (Figure 8.4.13). The Henry Mountain bison herd began in 1941 when 18 Yellowstone National Park bison were relocated to the Henry Mountains. The trend in the Henry Mountain adult and yearling bison pre-season population has been somewhat variable at adult and yearling numbers, from around 300 to as high as 559 in 1990 and back to 313 in 2009 (Figure 8.4.10; Table 8.4.6).

According to the Utah Division of Wildlife Resources, current management practices include annual helicopter surveys, summer ground classification, sport harvest, and extensive habitat management. Population estimates are derived annually based on the number of animals counted during the surveys, count conditions, ground classification, the number of animals harvested, and a 5 percent natural mortality rate (UDWR, 2007).

Those 18 animals increased to 308 adult and yearling bison in 1983, prior to the fall hunting season. A herd cap of 200 adults and yearling bison (post season) was set in 1983 and increased to 275 (post-season adults and yearlings) in 1995 with the purchase of livestock AUMs from local ranchers. The UDWR captured 45 Henry Mountain bison and released them into the Book Cliffs in 2008 and 2009. These two bison herds utilize over 1.6 million acres of habitat, approximately 3 percent of the state (Table 8.4.4). Almost the entire habitat has been classified as crucial (98 percent), with a small amount classified as substantial (2 percent) (Table 8.4.5).

In addition to the Henry Mountain and Book Cliffs herds, there are also two bison herds on Antelope Island State Park and on the Ute Tribe Hill Creek Extension. The Utah Division of Wildlife Resources manages only the Henry Mountain and Book Cliffs herds. The Utah Division of Parks and Recreation manages the Antelope Island herd, and the Ute Tribe manages the herd on the Hill Creek Extension. Table 8.4.5 includes only the animals managed and reported by the Utah Division of Wildlife Resources. Post-harvest population estimates for all four bison herds in Utah in 2007 were as follows: Antelope Island, 500; Henry Mountains Unit 15, 340; Ute Tribe Hill Creek Extension, 580; and Book Cliffs Unit 10, 45. The total for 2007 was near 1,465 adults and yearlings.

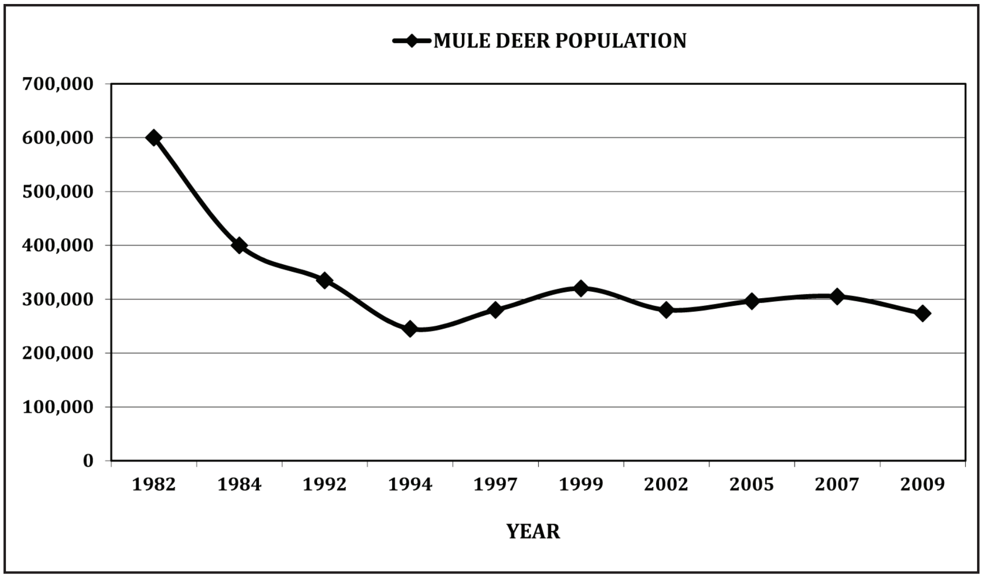


Figure 8.4.2. Estimated population and trend of mule deer in Utah (1982-2009).
Sources: Same as those reported in Table 8.4.6.

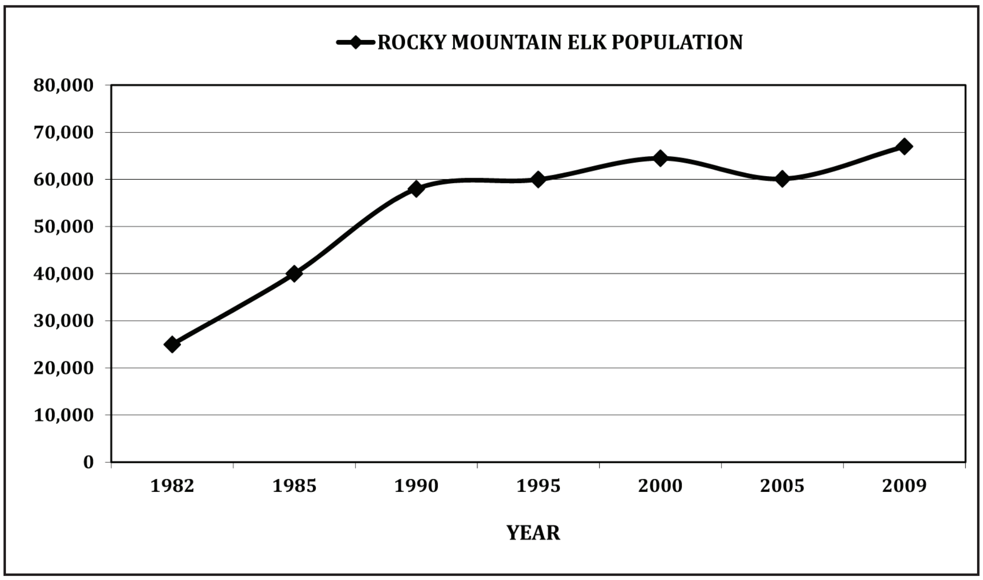


Figure 8.4.3. Estimated population and trend of Rocky Mountain elk in Utah (1982-2009).
Sources: Same as those reported in Table 8.4.6.

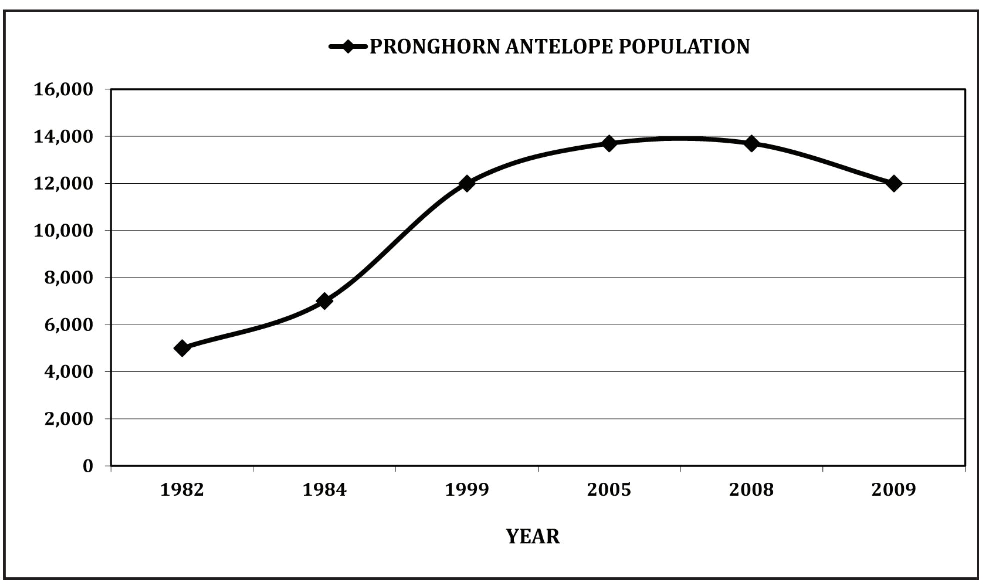


Figure 8.4.4. Estimated population and trend of pronghorn antelope in Utah (1982-2009).
Sources: Same as those reported in Table 8.4.6.

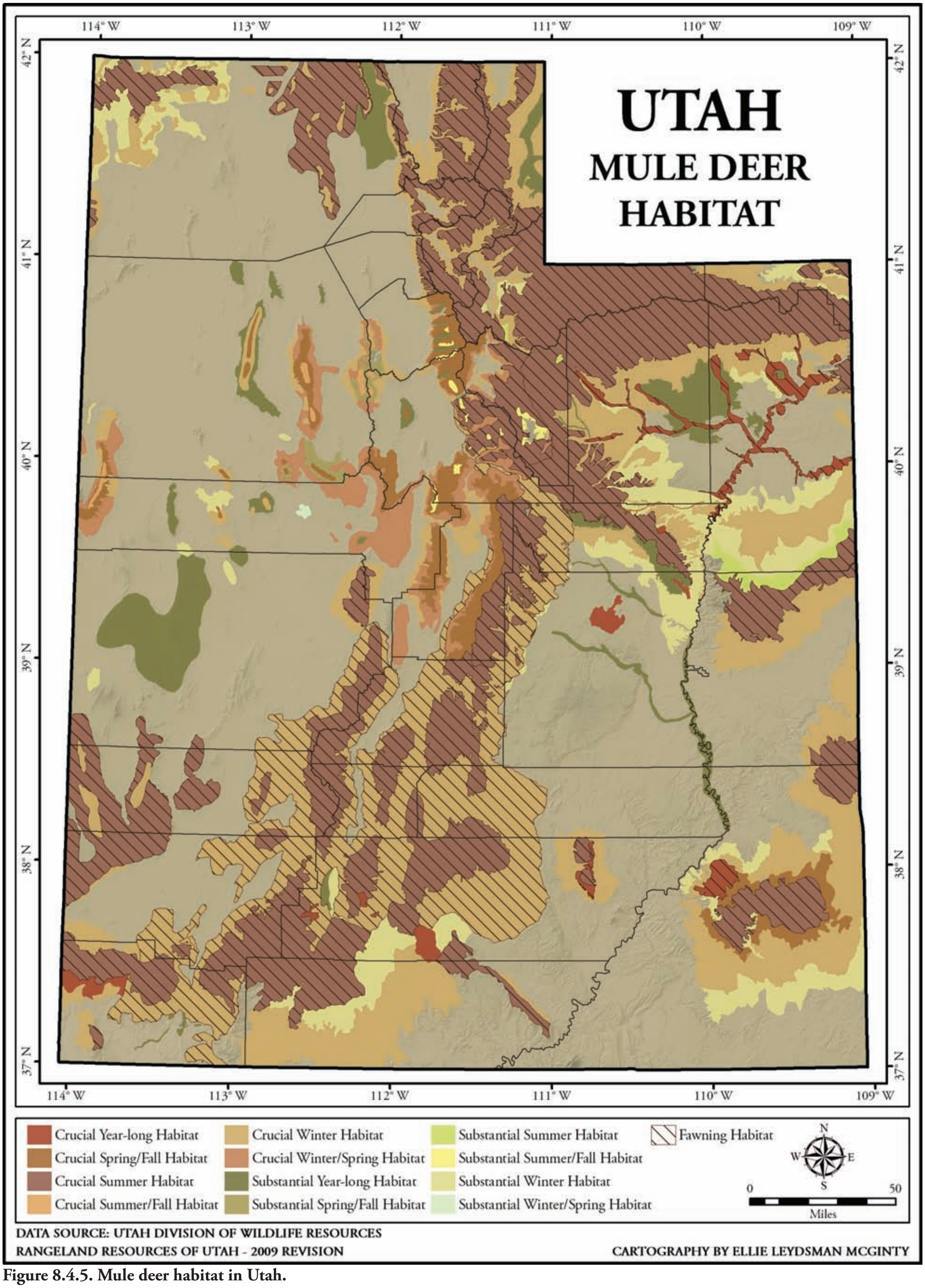


Figure 8.4.5. Mule deer habitat in Utah.

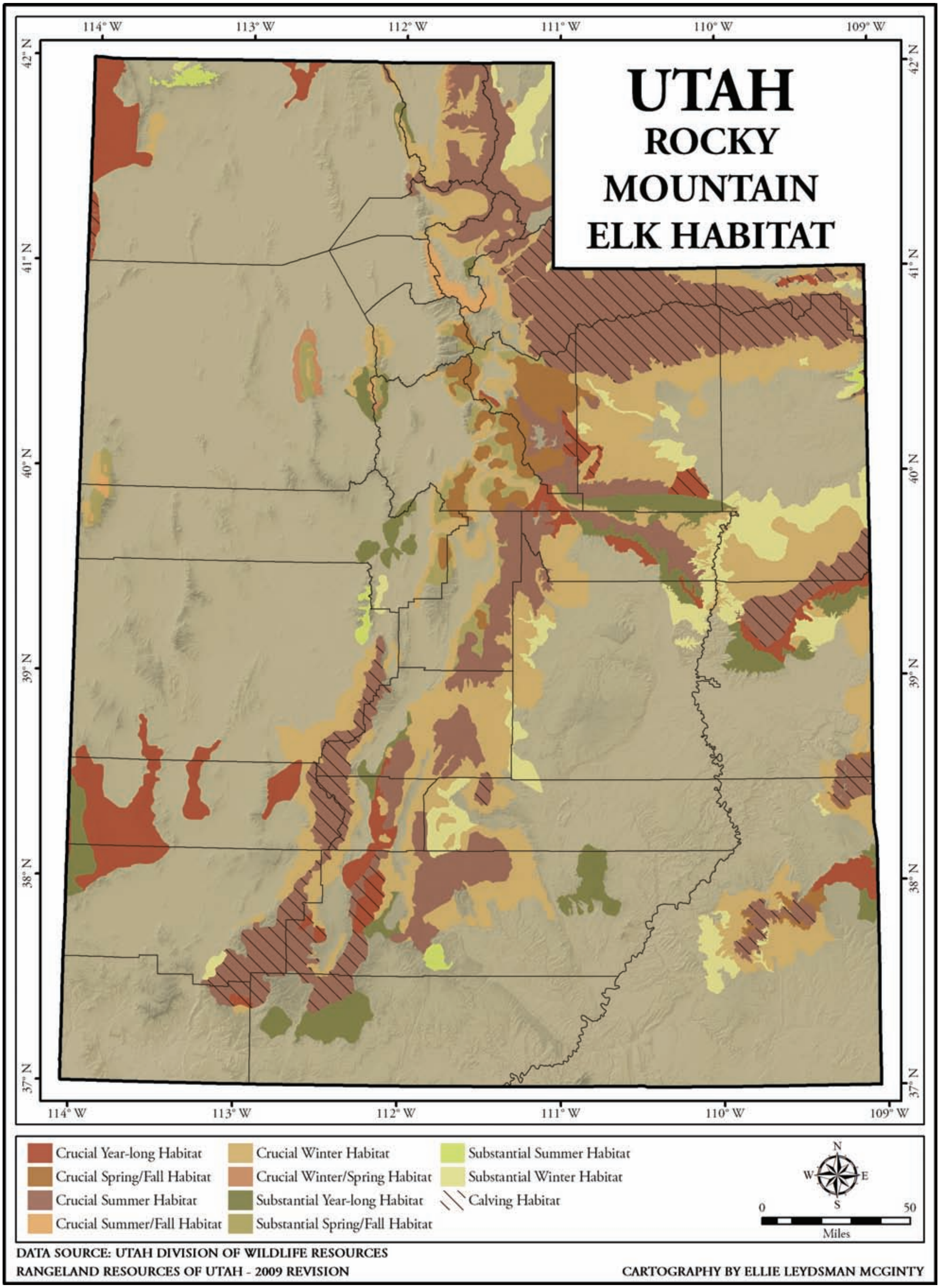


Figure 8.4.6. Rocky Mountain elk habitat in Utah.

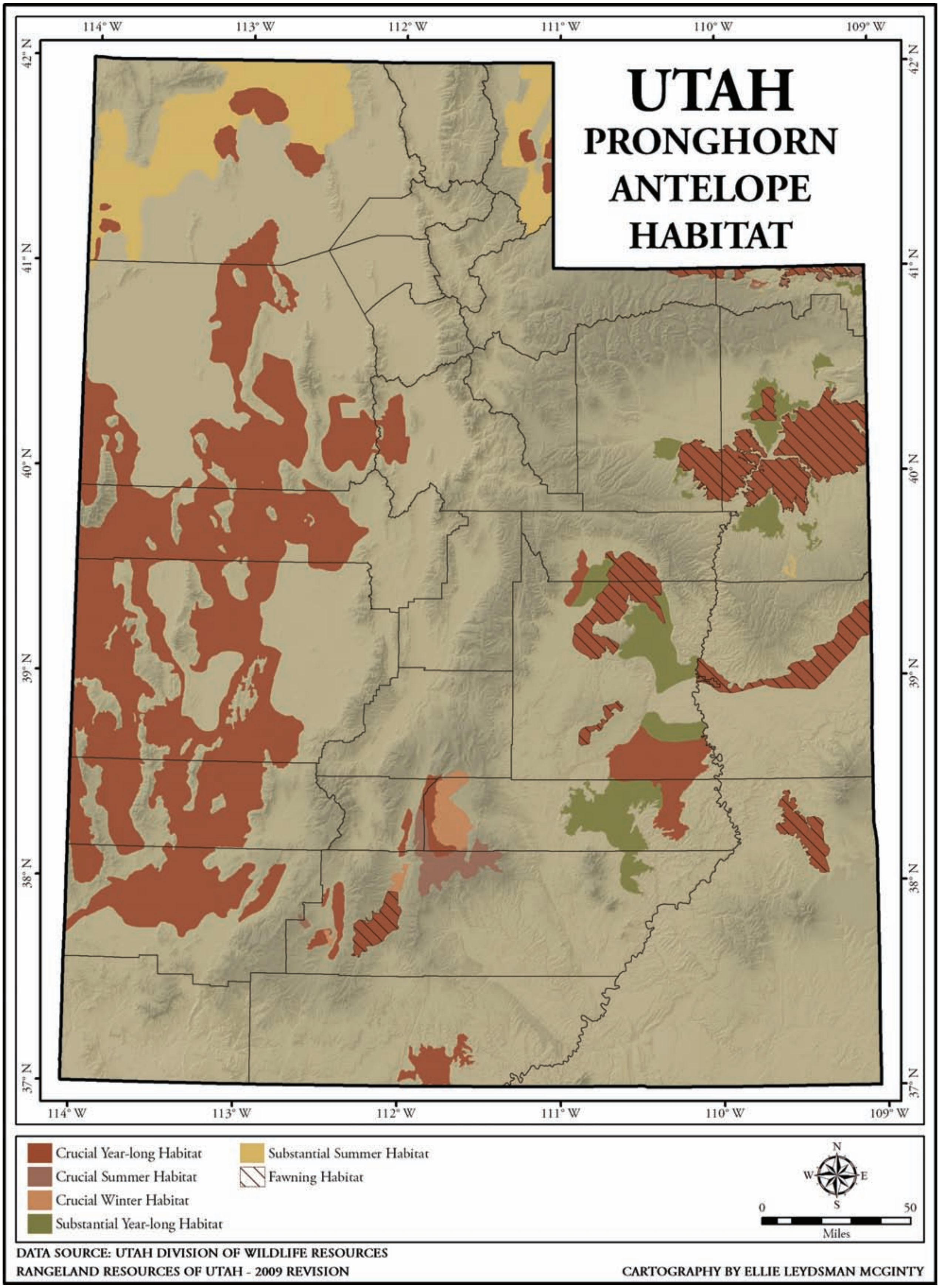


Figure 8.4.7. Pronghorn antelope habitat in Utah.

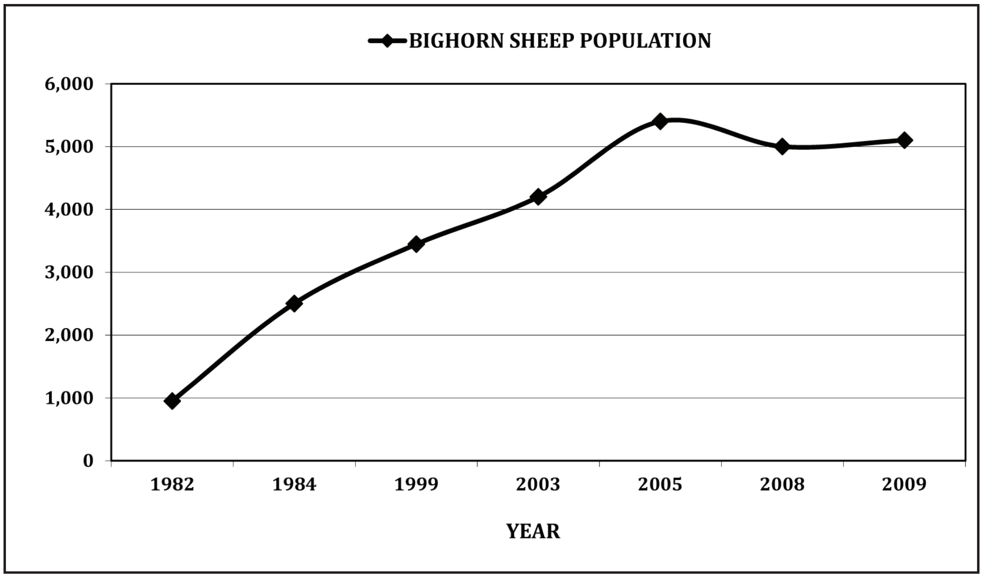


Figure 8.4.8. Estimated population and trend of bighorn sheep in Utah (1982-2009). Sources: Same as those reported in Table 8.4.6.

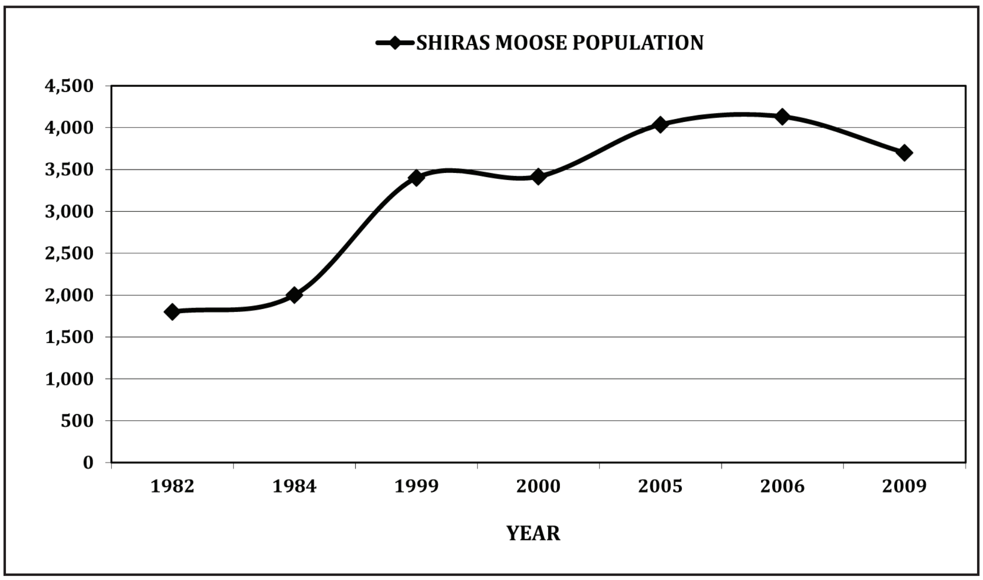


Figure 8.4.9. Estimated population and trend of Shiras moose in Utah (1982-2009). Sources: Same as those reported in Table 8.4.6.

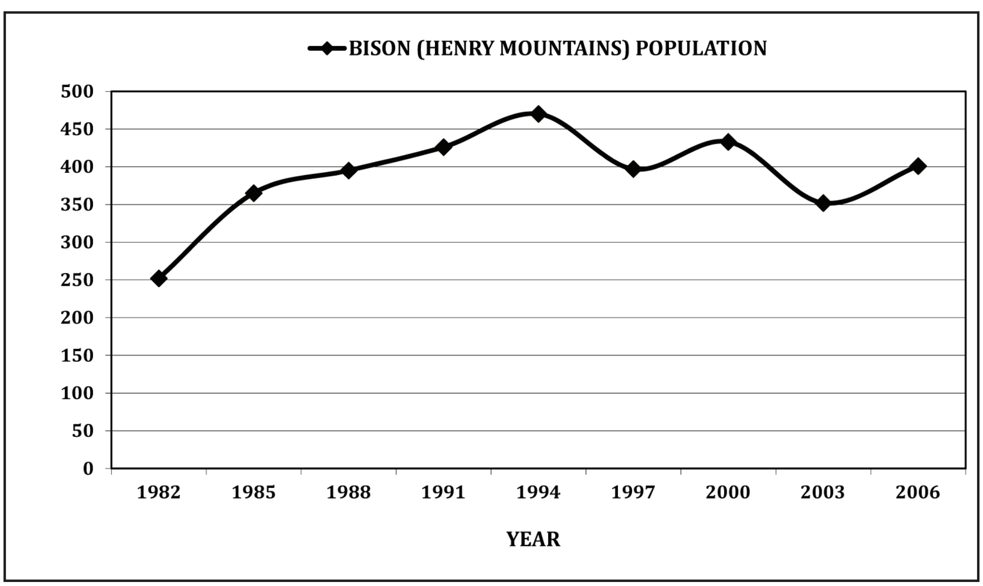


Figure 8.4.10. Estimated population and trend of the Henry Mountain bison herd in Utah (1982-2009). Sources: Same as those reported in Table 8.4.6.

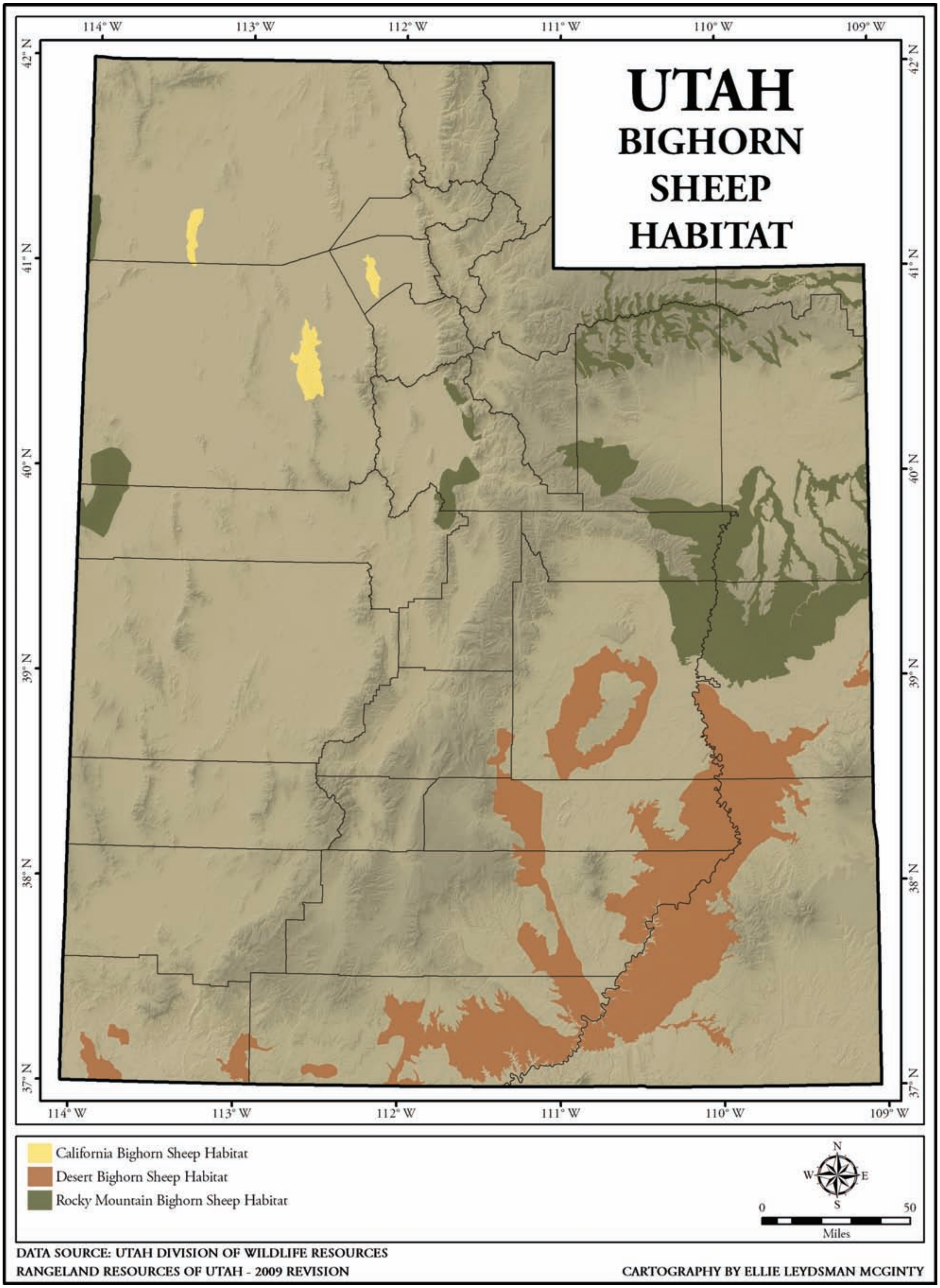


Figure 8.4.11. Bighorn sheep habitat in Utah.

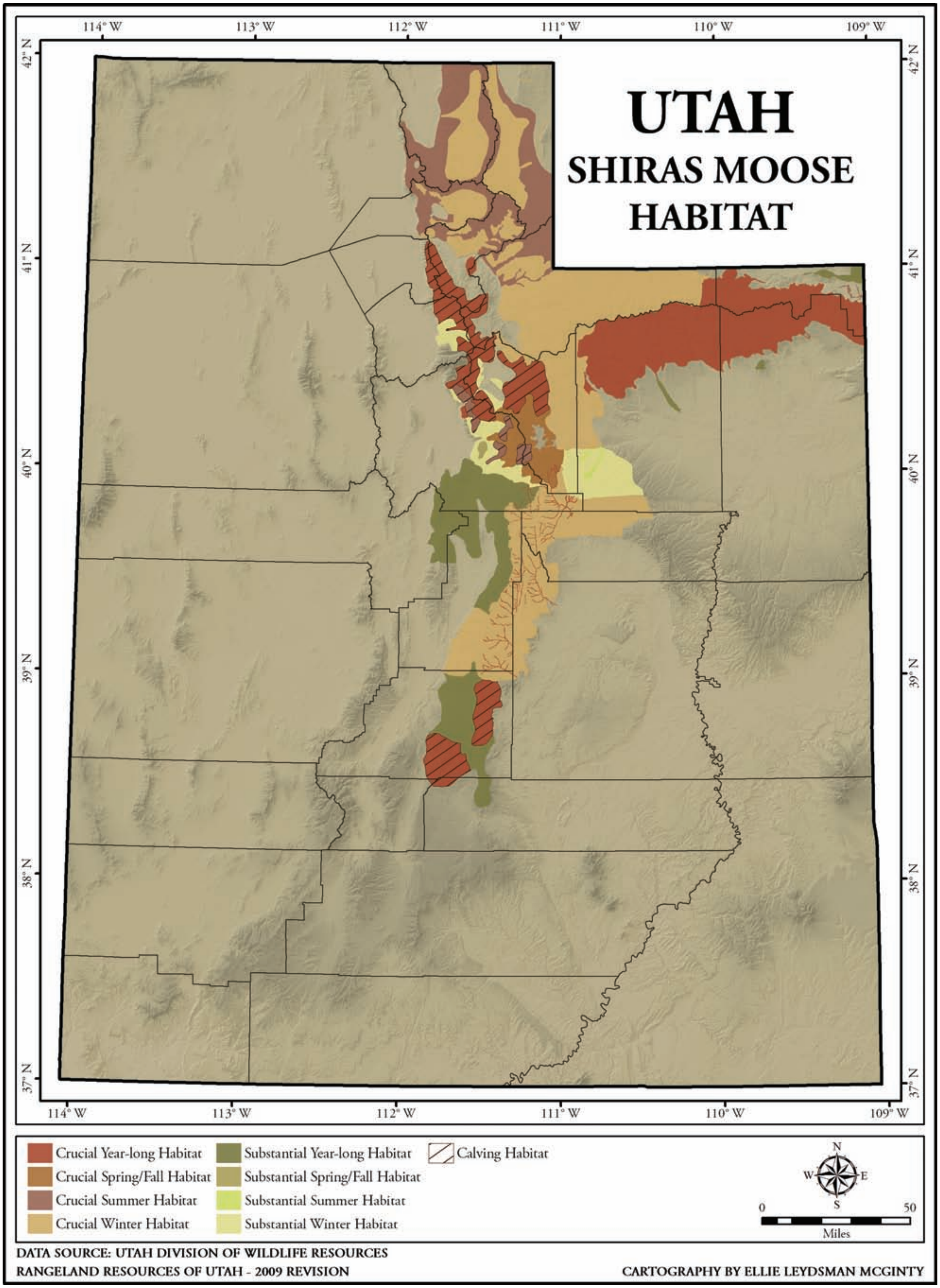


Figure 8.4.12. Shiras moose habitat in Utah.

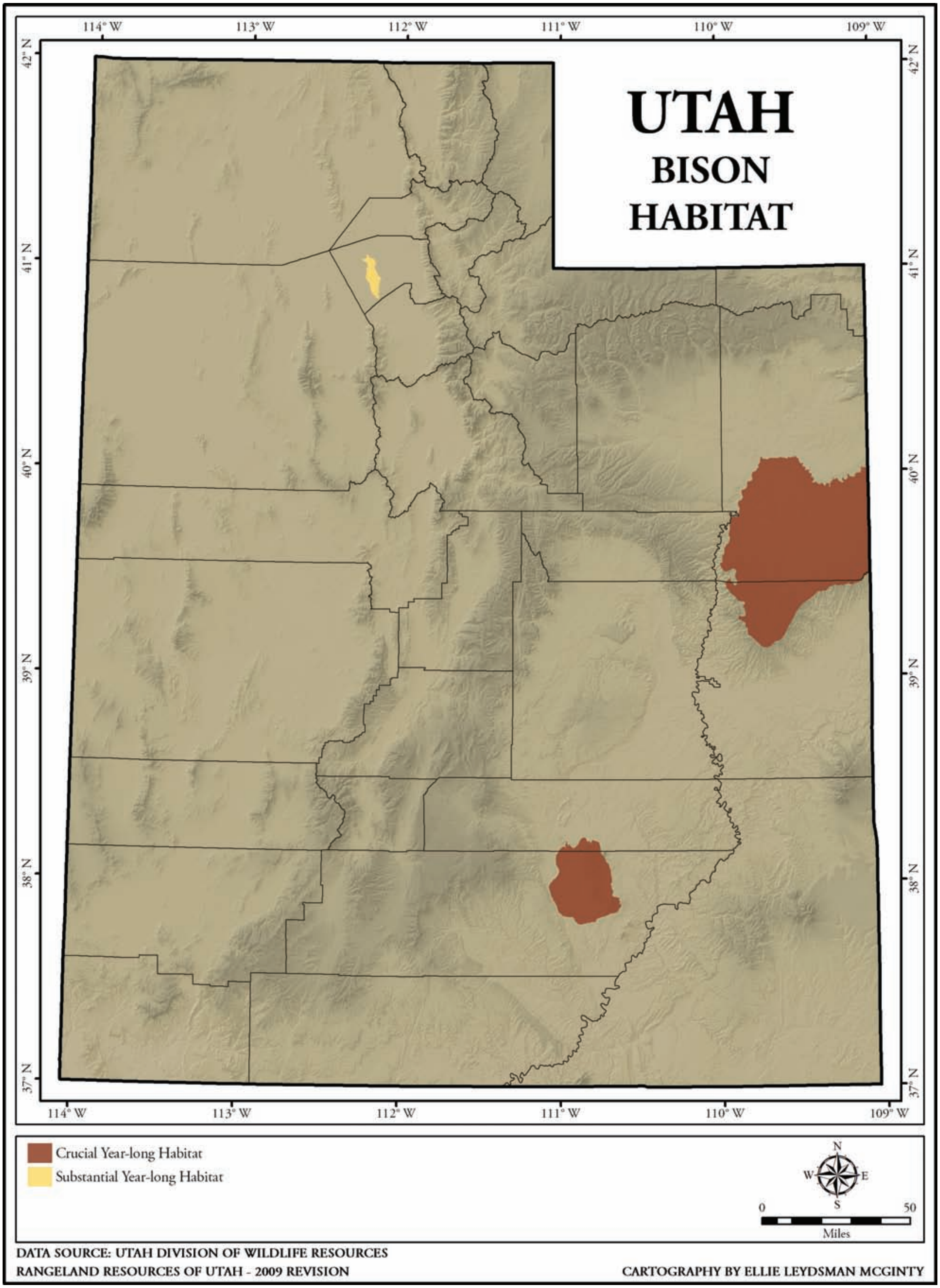


Figure 8.4.13. Bison habitat in Utah.

SPECIAL STATUS SPECIES

There has been a large increase in the designation of wildlife that requires special management over the past several decades. Utah has, or historically had, 21 federally listed (endangered or threatened) wildlife species, including five mammals, five birds, eight fish, one reptile, and two invertebrates. In addition, there are currently another four species that are candidate species for federal listing, including two vertebrates and two invertebrates. The Utah Division of Wildlife Resources indicated that species of concern increased from 64 in 1976 to 90 in 1998, and decreased to 74 in 2003 due to new criteria. In 2009, the UDWR identified 71 species of concern. The UDWR has also identified 90 conservation concern wildlife species, which require additional attention (Sutter et al., 2005). Every county in Utah has been identified as likely to have at least one federal or state designated species.

The Utah Division of Wildlife Resources has developed a Comprehensive Wildlife Conservation Strategy (CWCS), also known as the Utah Wildlife Action Plan. The CWCS is a proactive plan to restore and enhance populations and habitats of specially designated wildlife species. Emphasis is on preventing the wildlife from becoming endangered and requiring additional protection under the Endangered Species Act (ESA). The UDWR adopted a three-tiered system that categorizes and prioritizes Utah's native animal species according to conservation need (Table 8.4.7). Tier I species include all federally listed species (candidate, threatened, or endangered) (Figures 8.4.14, 8.4.15, and 8.4.16). Tier I species also include species for which a Conservation Agreement has been completed and implemented (Figure 8.4.17). Tier II species are under sole state authority and include those listed on the Utah Species of Concern list (Figure 8.4.18). Tier III includes species that are of conservation concern due to at-risk habitat, marked population declines, or limited ecological or status information. The tiered ranking system provides a perspective for wildlife managers to prioritize conservation activities. For example, Washington County has the highest occurrence of sensitive species (candidate for federal listing, federally listed threatened species, federally listed endangered species, state of Utah Conservation Agreement Species, and State of Utah Species of Concern) in the state of Utah (Figure 8.4.19).

Table 8.4.7. Utah special status species.

TAXA GROUPING	TOTAL	TIER I[a]	TIER II[b]	TIER III[c]
AMPHIBIAN	10	2	2	6
BIRD	44	8	12	24
FISH	29	15	7	7
MAMMAL	39	5	14	20
MOLLUSK	41	5	24	12
REPTILE	34	1	12	21
TOTAL	197	36	71	90

[a]Tier I - Federally listed candidate, threatened, or endangered species.
[b]Tier II - State of Utah species of concern.
[c]Tier III - Utah designated species that require additional attention.
Source: Utah Division of Wildlife Resources Comprehensive Wildlife Conservation Strategy (CWCS).

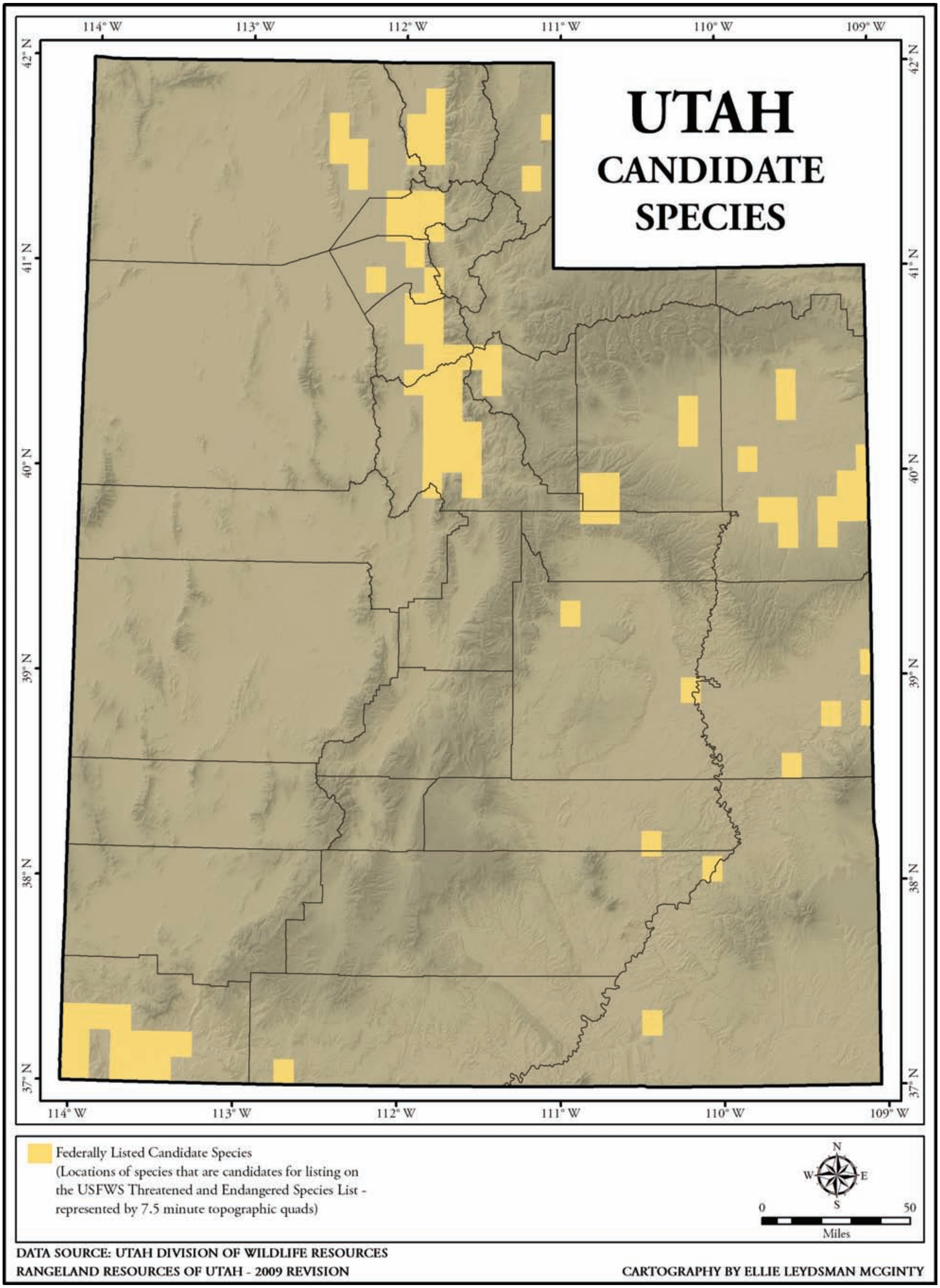


Figure 8.4.14. Locations of federally listed candidate species represented by 7.5 minute topographic quads.

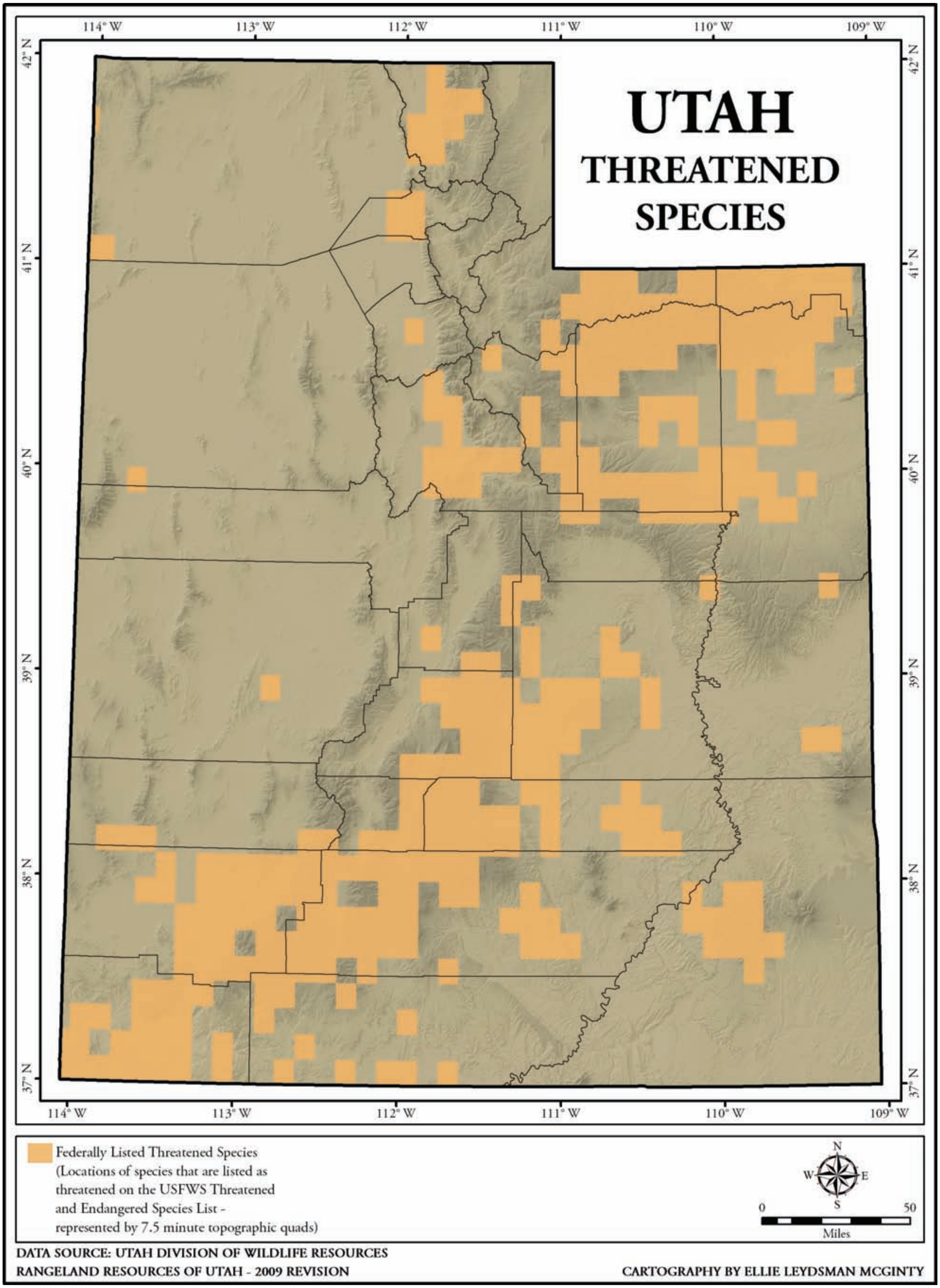


Figure 8.4.15. Locations of federally listed threatened species represented by 7.5 minute topographic quads.

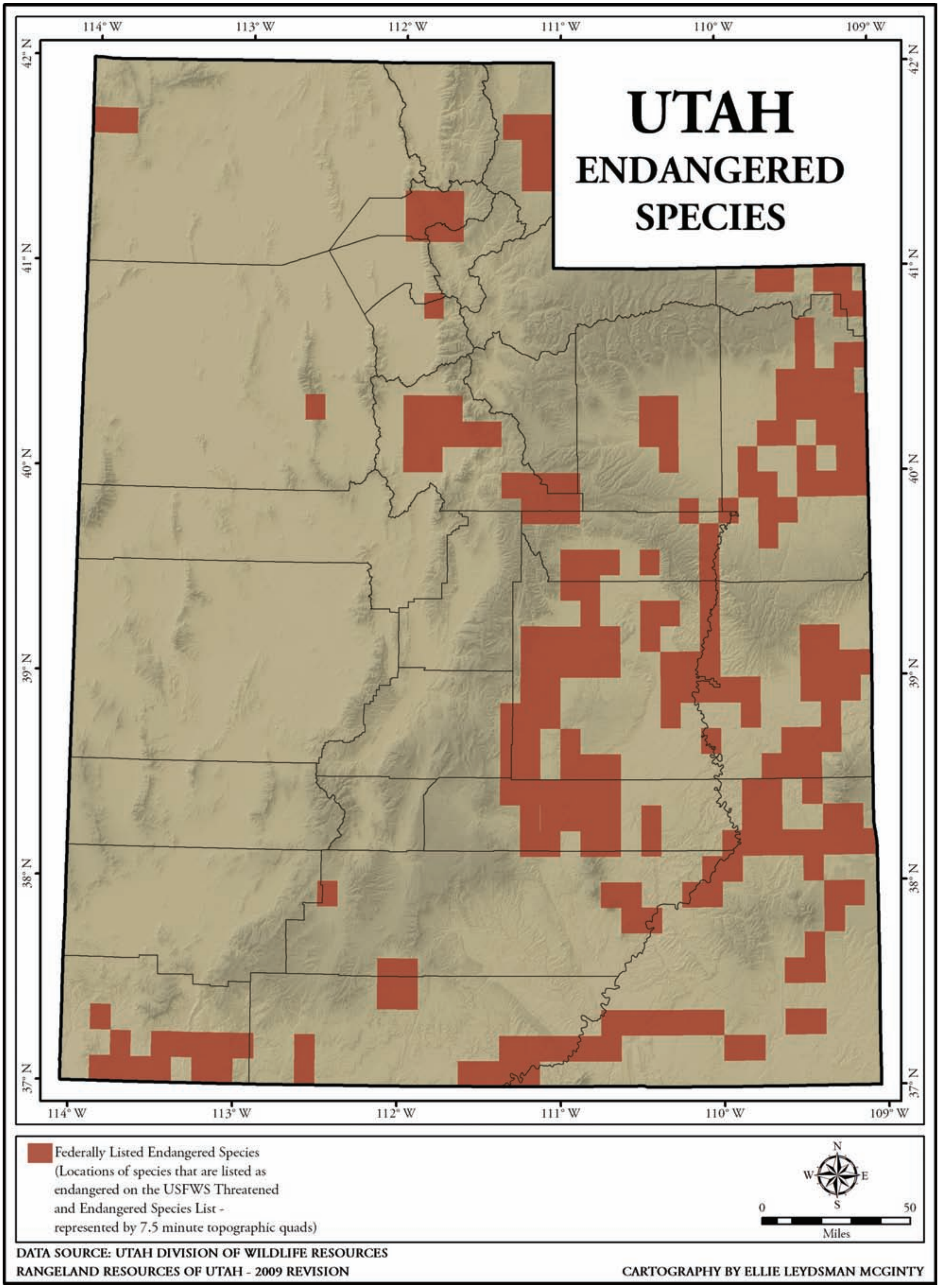


Figure 8.4.16. Locations of federally listed endangered species represented by 7.5 minute topographic quads.

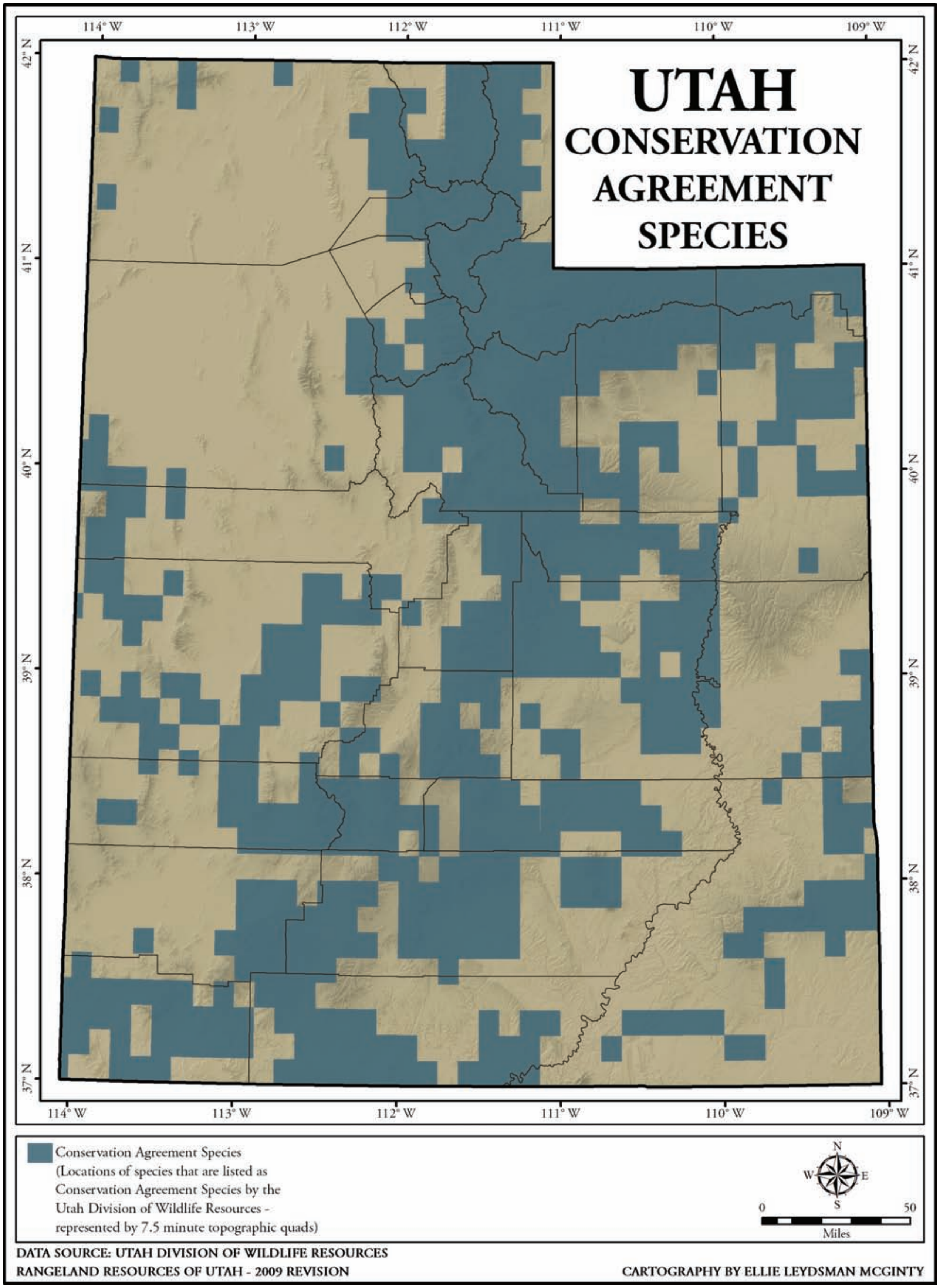


Figure 8.4.17. Locations of Utah Conservation Agreement Species represented by 7.5 minute topographic quads.

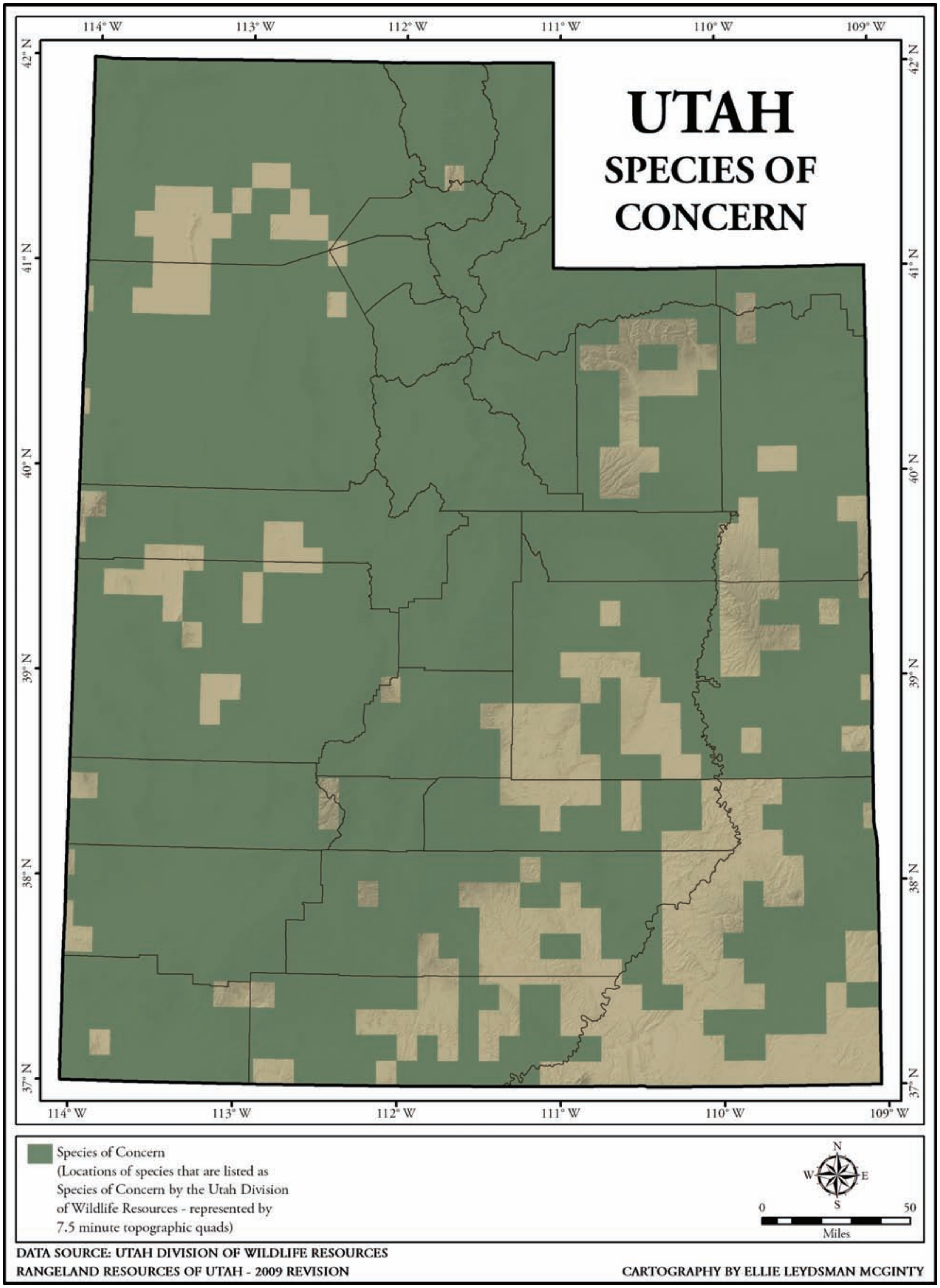


Figure 8.4.18. Locations of Utah Species of Concern represented by 7.5 minute topographic quads.

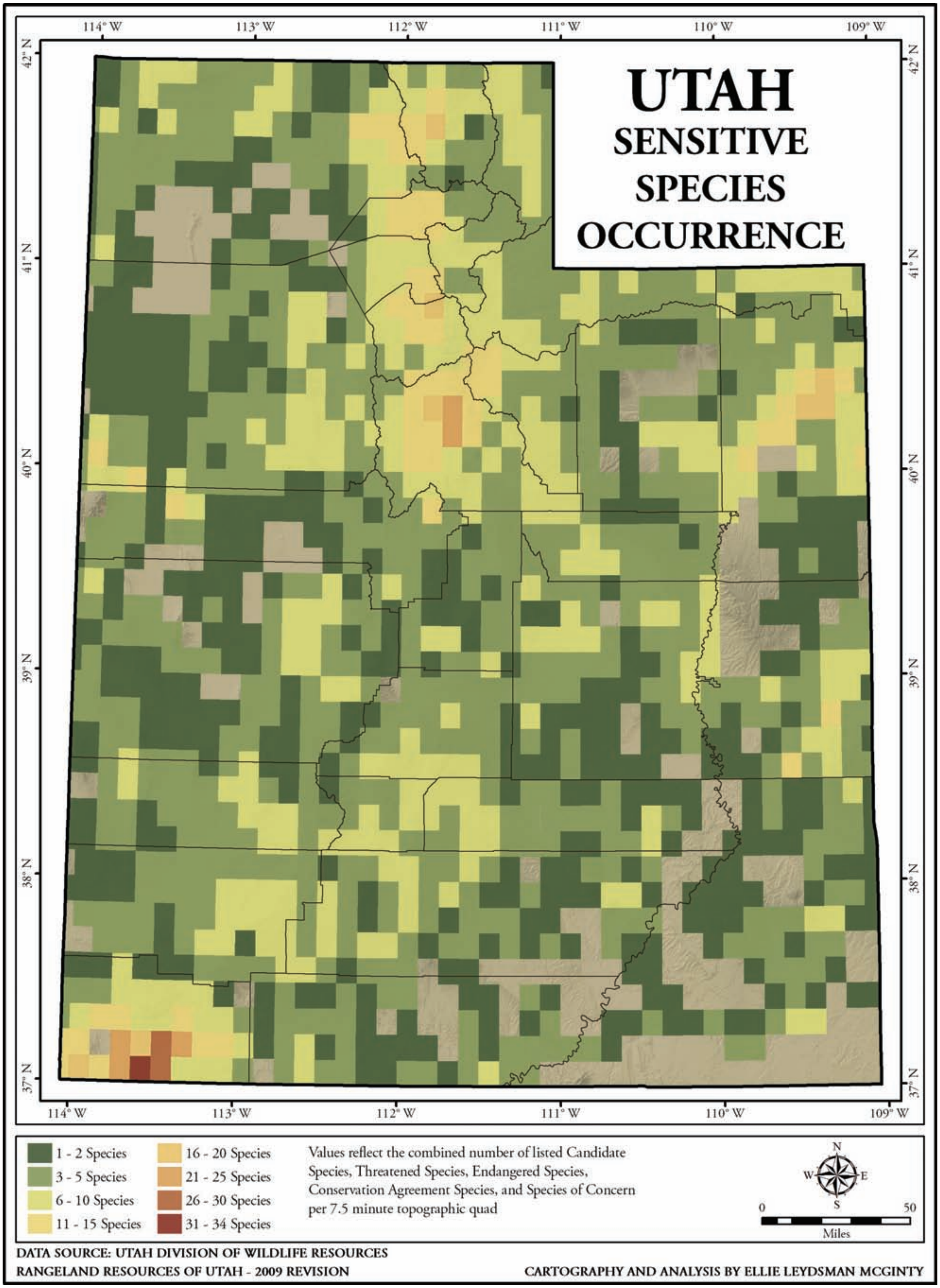


Figure 8.4.19. Sensitive species occurrence in Utah. Includes occurrence of federally listed candidate, threatened, and endangered species and state of Utah Conservation Agreement Species and Species of Concern.

WILD HORSE AND BURROS

There are approximately 3,000 wild horses and burros in Utah. These unbranded and unclaimed free-roaming horses and burros on BLM-administered public lands are managed, controlled, and protected in accordance with the 1971 Wild Free-Roaming Horses and Burros Act (as amended by Congress in 1976, 1978, 1996, and 2004). Wild horses and burros are managed by the BLM as part of its multiple-use mission under the Federal Land Policy and Management Act of 1976.

The BLM data reports (estimated population information as of February 29, 2008) there were 3,096 wild horses and burros (2,892 horses and 204 burros) roaming on BLM-managed lands in Utah. More than 3.8 million acres in 15 counties have been identified as wild horse and burro habitat, labeled as herd areas (Figure 8.4.20). Within this area, over 2.7 million acres (71.7 percent) have been certified as herd management areas (HMA), which are areas actively managed for wild horses and burros. More than 87 percent of 2.3 million acres of the HMAs occur on BLM-administered land. There are 21 identified HMA, including three complexes that incorporated several small areas.

The BLM sets appropriate management levels (AML) for each herd management area to sustain the health and productivity of the public lands. In 2008, the statewide AML was set at 1,981 for wild horses and 170 for burros. The estimated wild horse population exceeds the AML by 911 animals, or 46 percent. The estimated burro population exceeds the AML by 34 animals, or 20 percent. Herd Management Areas were at or below their appropriate management levels.

The BLM is authorized to remove excess wild horses and burros from areas exceeding the established AML. From fiscal year 1972 to fiscal year 2008, the BLM removed more than 6,700 wild horses and burros from Utah public rangelands, while placing more than 3,500 into private care through adoption (Table 8.4.8). Since 1971, more than 5,900 wild horses and more than 500 burros have been adopted.

Table 8.4.8. Bureau of Land Management wild free-roaming horse and burro adoptions and removals in Utah.

YEAR	ANIMALS ADOPTED		ANIMALS REMOVED	
	HORSES	BURROS	HORSES	BURROS
1996	326	53	221	55
1997	496	26	365	0
1998	291	22	160	0
1999	255	12	163	0
2000	257	18	1,268	0
2001	248	28	646	132
2002	221	19	1,337	0
2003	141	28	375	0
2004[a]	167	21	627	0
2005	173	20	248	0
2006	175	54	628	0
2007	246	34	312	0
2008	173	32	95	83
1972-2008	5,923	509	6,445	270

[a]Beginning in 2004, adoption numbers were adjusted downward to account for animals that have returned and been re-adopted.
Source: Bureau of Land Management Public Land Statistics.

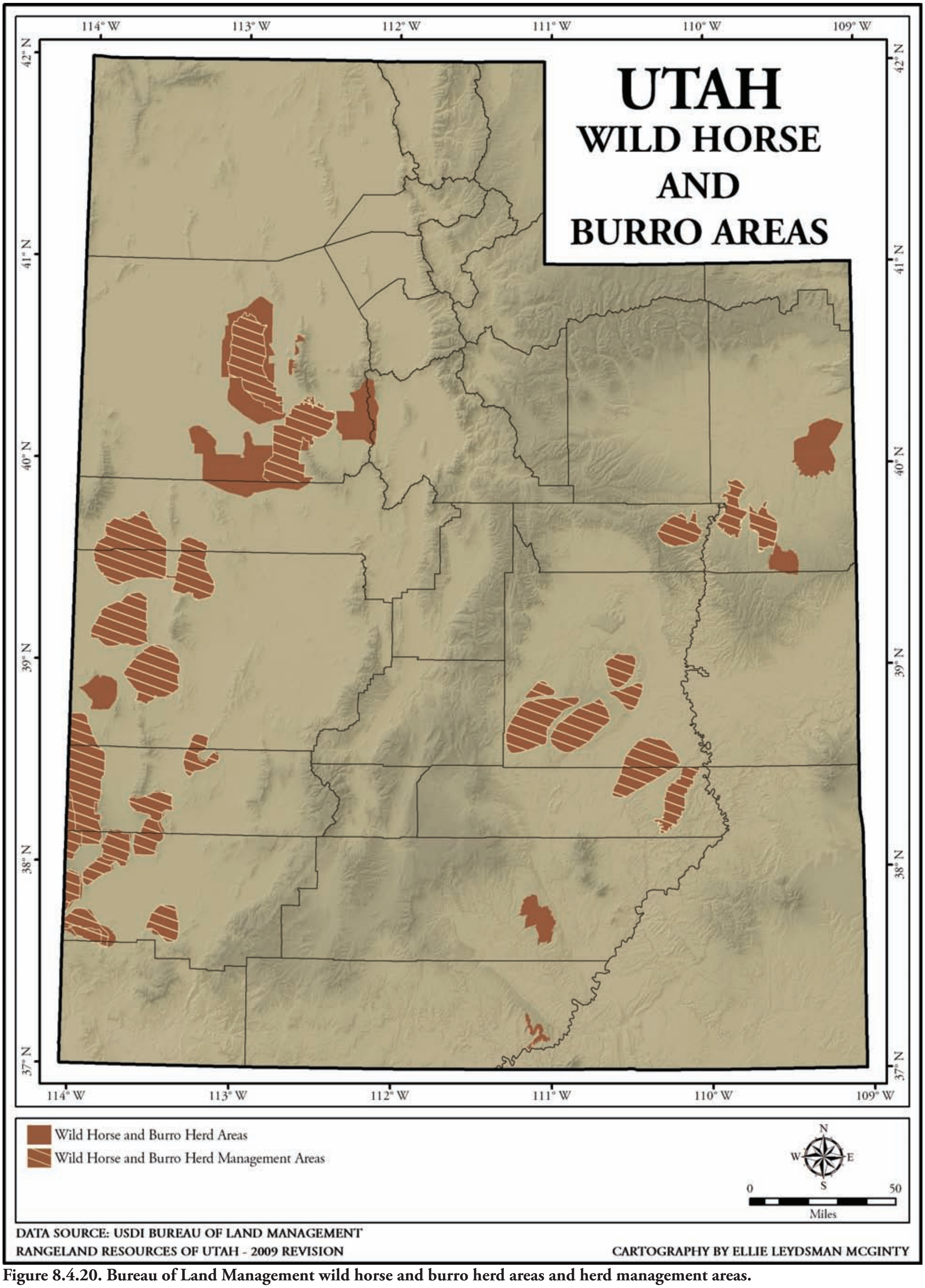


Figure 8.4.20. Bureau of Land Management wild horse and burro herd areas and herd management areas.

NOTES

Note concerning habitat calculations – All calculations for wildlife habitat were made using Geographic Information Systems (GIS) based on Utah Division of Wildlife Resources data. All habitat calculations related to land administration were made using ArcGIS 9.3 based on data retrieved from the Utah Automated Geographic Reference Center (AGRC). Differences in reported acreages reflect inherent differences in the original data sets, including accuracy and precision of source data and base maps. Data have been reported as calculated to preserve the intent of the source data.

Note concerning special status maps – The special status maps represent Utah's special status wildlife species. These maps were created utilizing current publicly available data. The maps represent known sightings and likely occurrences of species based on recorded documentation. The maps are depicted utilizing the United States Geological Survey 7.5 minute topographic quadrangle maps, thus resulting in a coarse data set.

RECREATION IN UTAH

Michael F. Butkus

LANDS USED FOR RECREATION

Outdoor recreation in the United States has seen a steady increase in participation since the end of World War II. Several factors have contributed to this trend, including more predictable leisure time for the average worker due to more stability in the average work day and work week; more disposable income due to increased wages, economic stability, and reasonable cost of living increases; better, more convenient access to outdoor recreation areas through improvements in roads and highways, particularly the development of the interstate highway system and more reliable personal transportation; improved non-motorized and motorized recreational trail systems; and significant improvements in outdoor recreation equipment to include lighter weight tents and backpacks, weather-resistant clothing, improved cooking utensils, camping trailers and recreational vehicles, four-wheel drive and high-clearance vehicles, and many more activity-specific items that have increased participation in a expanding variety of outdoor recreation activities.

This trend in steadily increasing participation in outdoor recreation certainly holds true for Utah. Utah offers an exceptionally wide variety of outdoor recreation opportunities, ranging from downhill skiing in the northern mountains to hiking along trails in the red rock canyons of the south. Most of the outdoor recreation occurs on public lands managed by a variety of federal and state agencies (Figure 8.5.1). Federal land management agencies, with missions of multiple uses of the lands they are responsible for, such as the Forest Service and Bureau of Land Management, manage public lands that accommodate the majority of both outdoor recreation and rangeland activities. Popular outdoor recreation activities in Utah include driving for pleasure, off-highway vehicle use, walking/hiking, wildlife viewing, camping, mountain biking, boating, fishing, hunting, and picnicking.

PRIVATE LANDS

The past two decades have seen a dramatic increase in the use of private land for outdoor recreational use by the public. This is due primarily to the overcrowding of recreationists or the decrease in quality of recreation opportunities on public lands. There has been a significant increase in the numbers of small farms and ranches turning to nature-based tourism or outdoor recreation activities to supplement their income from traditional farming and ranching activities. Examples of this include dude ranches; hunting, fishing, and wildlife viewing on private lands; and private land owners either developing their own motorized or non-motorized trail systems or allowing trail systems originating on public lands to extend onto their land for financial recompense.

STATE LANDS

Most of the state parks in Utah are too small or have policies that do not allow domestic livestock grazing and other rangeland activities to occur within their boundaries. The total land area dedicated to state parks in Utah is 119,304 acres or about 0.2 percent of the total state land area. The 43 state parks in Utah (Table 8.5.1) receive over 4.5 million visits per year.

The Division of Wildlife Resources manages land areas and facilities that accommodate or support outdoor recreation activities including the Hardware Ranch Wildlife Management Area, a popular wildlife viewing area; the Great Salt Lake Nature Center; and several fish hatcheries and hunter education centers around the state. The State of Utah School and Trust Lands Administration either manages or oversees the management of about 6.3 percent of the land area in Utah or 3,411,844 acres. Examples of outdoor recreation opportunities offered on state trust lands include the Beaver Mountain Ski Resort and several outdoor recreation cabin sites.

FEDERAL LANDS

National Park Service – The National Park Service (NPS) manages 3.9 percent of the Utah land area or about 2,095,381 acres. Management units within the NPS system in Utah include five national parks, six national monuments, one national recreation area, and one national historic site (Table 8.5.2). The NPS has a restricted use policy of land management with a two-part mandate to preserve lands under its jurisdiction for future generations while managing those lands for the enjoyment of the current population of the United States. The major way in which the current population enjoys lands managed by the NPS is through such outdoor recreation activities as driving for pleasure, sightseeing, and hiking. Visitation to NPS management units in Utah totals over 8.5 million per year. National Park Service policy does not allow for livestock grazing in most of its management units.

United States Fish and Wildlife Service – This is the other single or restricted-use federal agency that administers land in Utah, with its primary mandate to manage for healthy wildlife populations by protecting critical wildlife habitat areas in preserves and refuges. The United

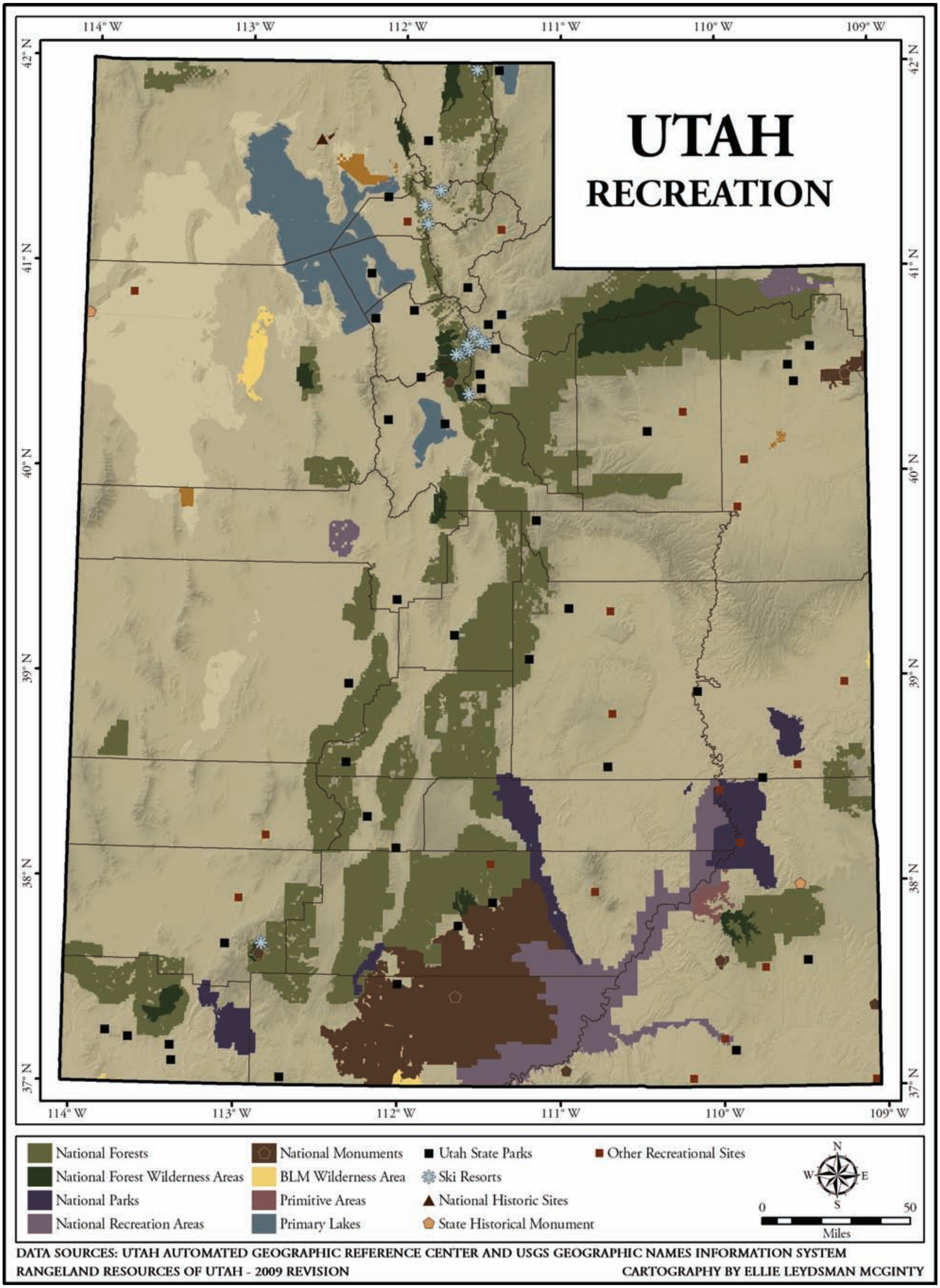


Figure 8.5.1. Recreational areas and sites in Utah (reference Tables 1-5 in Appendix D).

Table 8.5.1. Utah state parks.

STATE PARK	COUNTY
Anasazi State Park Museum	Garfield
Antelope Island State Park	Davis
Bear Lake State Park	Rich
Camp Floyd/Stagecoach Inn State Park	Utah
Coral Pink Sand Dunes State Park	Kane
Dead Horse Point State Park	Grand
Deer Creek State Park	Wasatch
East Canyon State Park	Morgan
Edge of the Cedars State Park	San Juan
Escalante Petrified Forest State Park	Garfield
Flight Park State Recreation Area	Salt Lake and Utah
Fremont Indian State Park	Sevier
Goblin Valley State Park	Emery
Goosenecks State Park	San Juan
Great Salt Lake State Marina	Salt Lake
Green River State Park	Emery
Gunlock State Park	Washington
Historic Union Pacific Rail Trail State Park	Summit
Huntington State Park	Emery
Hyrum Reservoir State Park	Cache
Iron Mission State Park	Iron
Jordan River State Park	Salt Lake
Jordanelle Reservoir State Park	Wasatch
Kodachrome Basin State Park	Kane
Millsite State Park	Emery
Otter Creek State Park	Piute
Palisade State Park	Sanpete
Piute State Park	Piute
Quail Creek State Park	Washington
Red Fleet State Park	Uintah
Rockport State Park	Summit
Sand Hollow State Park	Washington
Scofield Reservoir State Park	Carbon
Snow Canyon State Park	Washington
Starvation Reservoir State Park	Duchesne
Steinaker State Park	Uintah
Territorial Statehouse State Park	Millard
This is the Place Heritage Park	Salt Lake
Utah Field House of Natural History	Uintah
Utah Lake State Park	Utah
Wasatch Mountain State Park	Wasatch
Willard Bay State Park	Box Elder and Weber
Yuba State Park	Juab

States Fish and Wildlife Service (USFWS) manages about 80,833 acres or 0.15 percent of the land area in Utah. One of the USFWS management units in Utah is the Bear River Migratory Bird Refuge (Table 8.5.2). Outdoor recreation activities occurring on USFWS management units include wildlife viewing, bird watching, hunting, and fishing.

United States Forest Service – Areas managed by the United States Forest Service (USFS) for multiple-use within the state of Utah attract more than 12.9 million visitors participating in recreation activities each year. The land area managed by the USFS totals about 8,159,000 acres, including about 767,000 acres of designated wilderness areas (Table 8.5.3), or about 15 percent of the state. Management units of the USFS in Utah include seven national forests, three of which share a central administrative staff, and the Flaming Gorge National Recreation Area. These public lands managed by the USFS offer opportunities for a wide variety of outdoor recreation activities, including downhill and cross country skiing, snowmobiling, off-road vehicle riding, mountain biking, hiking, backpacking, developed and dispersed area camping, hunting, fishing, driving for pleasure, boating activities, and swimming.

Bureau of Land Management – The Bureau of Land Management (BLM) manages the greatest number of acres of land in Utah – over 22.7 million acres or 42 percent of the state. More than 6.7 million people visit lands managed by the BLM each year to participate in outdoor recreation activities. The BLM has a policy of managing the public lands under its responsibility for multiple-use. The BLM also manages the Grand Staircase-Escalante National Monument (GSENM) (Table 8.5.2). This was the first of several national monuments designated for the BLM to manage during the end of the Clinton Administration. Management policies for national monuments under the jurisdiction of the BLM differ significantly from the general policy of multiple-use management, following somewhere between traditional multiple-use and the more restrictive policies of the National Park Service. Consequently, a major land management dispute exists between the BLM and livestock grazers, who have traditionally used the area encompassed by the GSENM, caused by the BLM being forced to implement policies severely restricting such use after the national monument was designated by President Clinton.

Other Federal Lands – Native American tribal governments manage over 2.5 million acres, about 4.5 percent, of land in Utah included in reservations. Outdoor recreation use of this land is restricted by the remote location of and difficult access to and within the reservations. Outdoor recreation activities that occur on tribal lands in Utah include hunting and some off-road vehicle riding. The Department of Defense (DOD) manages about 3.3 percent, a little over 1.8 million acres, in Utah. This land is almost all bombing/target ranges in the West Desert and is not normally open to the public.

OUTDOOR RECREATION AND RANGELAND ISSUES

Outdoor recreation participants can have a number of negative impacts on rangeland and the livestock grazing that occurs on it. Examples include trampling or destruction of rangeland vegetation through careless actions or overcrowding of outdoor recreation participants; introduction of noxious and invasive species of vegetation through seeds found in the droppings of recreation pack stock animals or in the soil transported in the tread of off-road vehicle tires; compaction and destruction of rangeland vegetation under snow in areas heavily used by snowmobilers; and erosion of soil on hillsides used for hill climbing by off-road motorcyclists.

Negative impacts on domestic livestock and the rangeland facilities to support them due to outdoor recreation can include harassment of livestock being chased by motorized vehicles; accidental or purposeful shooting of livestock by hunters during and prior to hunting seasons; hikers leaving gates open in allotment fences, resulting in livestock escaping into other allotments; and wanton destruction of allotment fences or livestock watering facilities by recreationists engaging in motorized recreation activities.

Of particular concern in the relationship between outdoor recreation and rangeland and its uses is the remarkable increase in the use of all-terrain vehicles (ATVs) on lands managed by the Forest Service and Bureau of Land Management. Several negative impacts to rangeland resources and livestock caused by motorized recreation participants were mentioned above. The Utah Division of Parks and Recreation, which oversees the registration of off-road vehicles such as ATVs and snowmobiles, reports that the number of ATV registrations increased from 77,503 in 1998 to 213,856 in 2008, an increase of over 275 percent. Much of the ATV riding occurs on public land that is also used for livestock grazing.

Conversely, livestock grazing can impact recreational use. *Giardia lamblia*, a bacterium that can cause gastric distress in humans, is commonly known to grow in the stomachs of warm-blooded animals, particularly ungulates. The bacteria are often transported into natural water sources that may be used by outdoor recreationists. Livestock grazing may also displace wildlife species valued for hunting or wildlife viewing.

Table 8.5.2. National recreation sites.

SITE	NAME	LAND ADMINISTRATOR
NATIONAL PARKS	Arches National Park	National Park Service
	Bryce Canyon National Park	National Park Service
	Canyonlands National Park	National Park Service
	Capitol Reef National Park	National Park Service
	Zion National Park	National Park Service
NATIONAL MONUMENTS	Cedar Breaks National Monument	National Park Service
	Dinosaur National Monument	National Park Service
	Grand Staircase-Escalante National Monument	Bureau of Land Management
	Hovenweep National Monument	National Park Service
	Natural Bridges National Monument	National Park Service
	Rainbow Bridge National Monument	National Park Service
	Timpanogos Cave National Monument	National Park Service
NATIONAL RECREATION AREAS	Flaming Gorge National Recreation Area	United States Forest Service
	Glen Canyon National Recreation Area	National Park Service
	Little Sahara National Recreation Area	Bureau of Land Management
NATIONAL HISTORIC SITE	Golden Spike National Historic Site	National Park Service
NATIONAL WILDLIFE REFUGES	Bear River National Wildlife Refuge	U.S. Fish and Wildlife Service
	Fish Springs National Wildlife Refuge	U.S. Fish and Wildlife Service
	Ouray National Wildlife Refuge	U.S. Fish and Wildlife Service

Table 8.5.3. United States Forest Service and Bureau of Land Management wilderness areas.

AREA	NAME	MANAGEMENT AREA
UNITED STATES FOREST SERVICE WILDERNESS AREAS	Ashdown Gorge	Dixie National Forest
	Box-Death Hollow	Dixie National Forest
	Dark Canyon	Manti-La Sal National Forest
	Deseret Peak	Uinta-Wasatch-Cache National Forest
	High Uintas	Ashley/Uinta-Wasatch-Cache National Forest
	Lone Peak	Uinta-Wasatch-Cache National Forest
	Mount Naomi	Uinta-Wasatch-Cache National Forest
	Mount Nebo	Uinta-Wasatch-Cache National Forest
	Mount Olympus	Uinta-Wasatch-Cache National Forest
	Mount Timpanogos	Uinta-Wasatch-Cache National Forest
	Pine Valley Mountain	Dixie National Forest
	Twin Peaks	Uinta-Wasatch-Cache National Forest
	Wellsville Mountains	Uinta-Wasatch-Cache National Forest
BUREAU OF LAND MANAGEMENT WILDERNESS AREAS	Beaver Dam Mountains	St. George Field Office
	Black Ridge Canyons	Moab Field Office
	Cedar Mountains	Salt Lake Field Office
	Paria Canyon-Vermilion Cliffs	GSENM/Kanab Field Office

ENERGY RESOURCES IN UTAH

Roger E. Banner

The unique geologic history, geography, and climate of Utah have resulted in an abundance of nonrenewable and renewable energy resources. Nonrenewable energy resources include fossil fuels, such as oil, coal, and natural gas, as well as naturally occurring elements, such as uranium. Renewable energy resources are those that are replenished by natural processes and include geothermal, solar, and wind energy. Additionally, water, when passed through hydroelectric power plants, and biomass, such as animal waste and landfill gas (methane), provide alternative renewable energy resources.

FOSSIL FUEL RESOURCES

Petroleum – Petroleum, also known as crude oil, is a flammable liquid comprised of hydrocarbons and other organic compounds that are naturally occurring and found in rock formations. Petroleum is refined in order to produce fuel for heating, power generation, and motor fuel.

In 1850, Captain Howard Stansbury noted signs of oil from a seep near Rozel Point on the northern shore of Great Salt Lake. By 1904, oil was being produced from the oil seep near Rozel Point, and oil had been found near Mexican Hat in southeastern Utah and near the town of Virgin in southwestern Utah. However, large-scale, commercial development did not begin until the 1940s and 1950s when oil wells were drilled in Vernal and in the Paradox Basin. Since the early 1960s, Utah has consistently ranked high among oil-producing states (UGS, 2009a; BEBR, 2007). Presently, the major oil and gas producing area in Utah is the Uinta Basin in the northeastern part of the state. However, other areas of fossil fuel production include Carbon and Emery counties, the Paradox Basin in San Juan County, the Uncompahgre Uplift in Grand County, the Thrust Belt in Summit County, and the recently discovered Covenant Field in the Central Utah Overthrust (Figure 8.6.1).

Utah contains three of the 100 largest oil fields in the United States and five petroleum refineries. Currently, there are 355 million barrels of proven oil reserves in the state. Crude oil production in Utah has seen a substantial resurgence over the past 5 years with the discovery of the Covenant Field in central Utah and increased exploration and drilling in the Uinta Basin. Crude oil production increased to 21.3 million barrels in 2008, up 9.1 percent from 2007 and up 63 percent from 2003 (Figure 8.6.2). The value of extracted crude oil in Utah for 2007 was more than $1.2 billion (UGS, 2009a).

While Utah currently has access to enough petroleum to meet its needs, prices are increasing and supplies are diminishing. Increases in population and wealth in Utah will probably result in increased demand for petroleum products, especially motor fuel. The increases in demand for gas and other petroleum products in Utah will be competing with increased demand from other rapidly-growing areas in the United States, as well as with other nations across the globe (UGS, 2009a).

Natural Gas Production – Natural gas is comprised of methane and other gases of organic origin. It is found in coal beds, natural gas fields, and oil fields. Before natural gas can be used as fuel, it must undergo extensive processing to remove all material other than methane.

In 1891, a water well in Farmington Bay near the Great Salt Lake was being drilled. At the depth of 1,000 feet, a pocket of natural gas was discovered. Gas from this area was piped to Salt Lake City in 1895 and 1896 through wooden pipelines until shifting sand in the lakebed plugged the wells (UGS, 2009a). Presently, Utah contains two of the 100 largest natural gas fields in the United States. More than 80 percent of Utah households use natural gas for heating; however, Utah only consumes about one-half of the production in the state. Natural gas is abundant in the Rocky Mountain region and continues to provide some of the least-expensive natural gas in the nation. Currently, the rate of natural gas consumption in Utah is increasing. Electric utilities have increased the use of natural gas power plants in the past few years. Natural gas is a rapidly growing industry and is an increasingly important natural resource for the state (Newell et al., 2008).

Natural gas production in Utah has seen a substantial increase in the past few years with the significant increase in drilling in the Uinta Basin. Utah produced a record high 418 billion cubic feet of natural gas in 2008, 8.5 percent more than in 2007 and 46 percent more than in 2003 (Figure 8.6.3). Marketed production and actual natural gas sales also reached record highs at 405 and 372 billion cubic feet, respectively. Approximately 19 percent of natural gas production was from coalbed methane wells, but this is decreasing as numerous new conventional wells are being drilled in the Uinta Basin and as existing coalbed methane wells are declining in production. The value of natural gas produced in Utah for 2007 was more than $1.5 billion (UGS, 2009a).

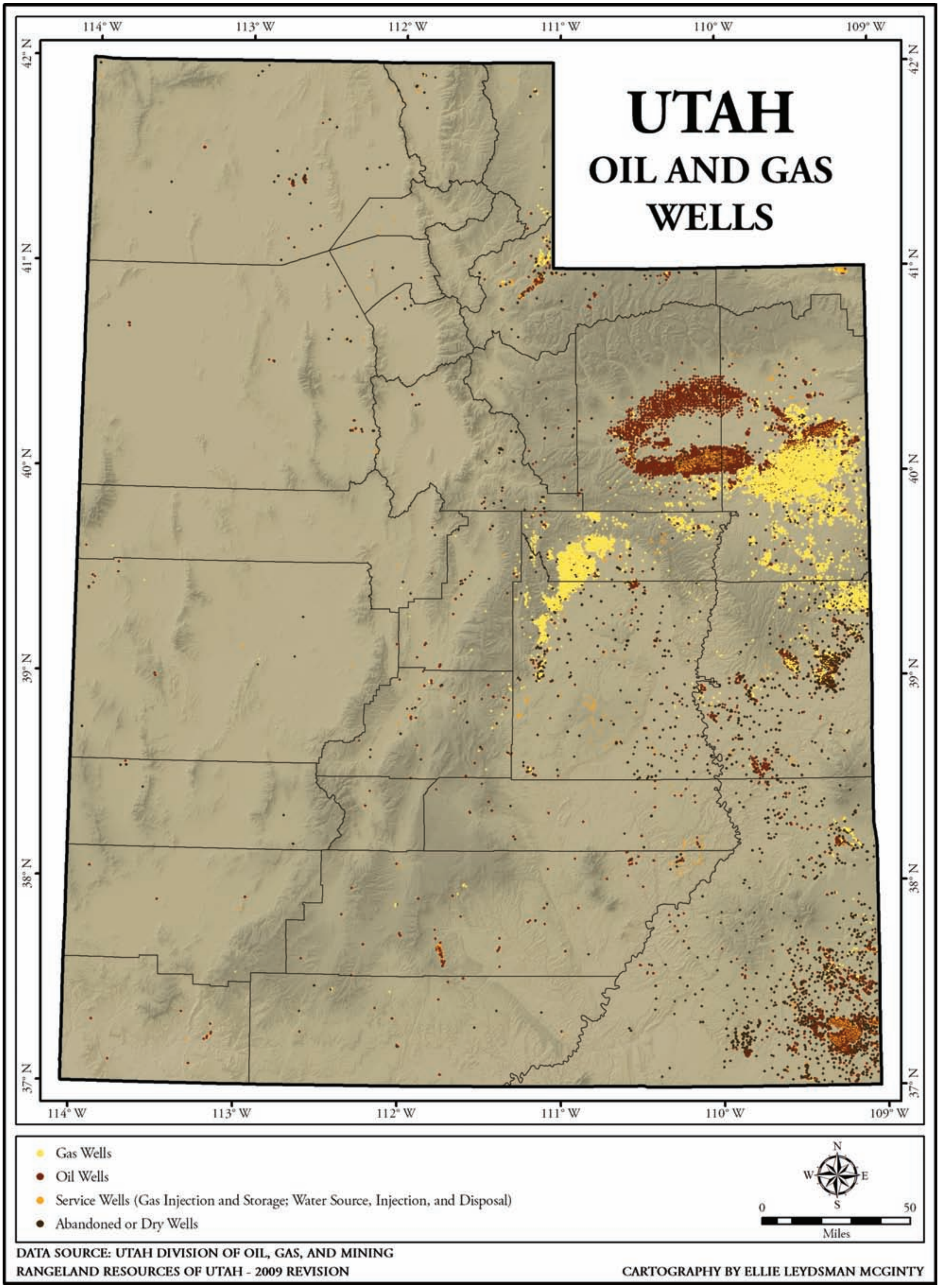


Figure 8.6.1. Oil and gas wells in Utah.

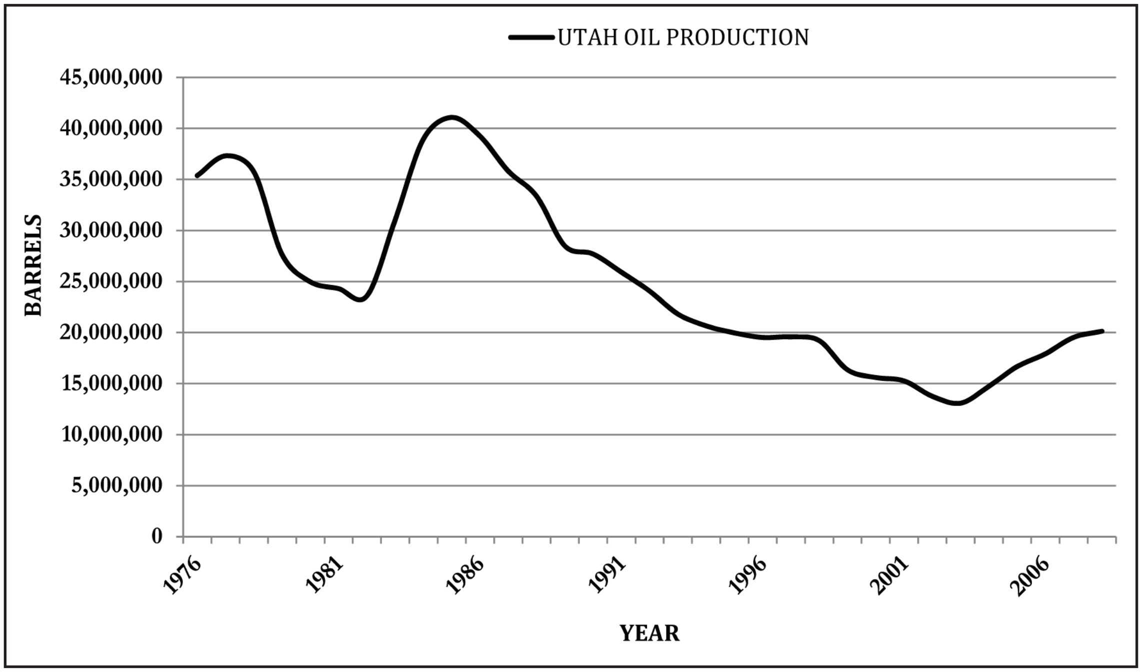


Figure 8.6.2. Oil production in Utah from 1976 to 2008.
Source: Utah Geological Survey (UGS).

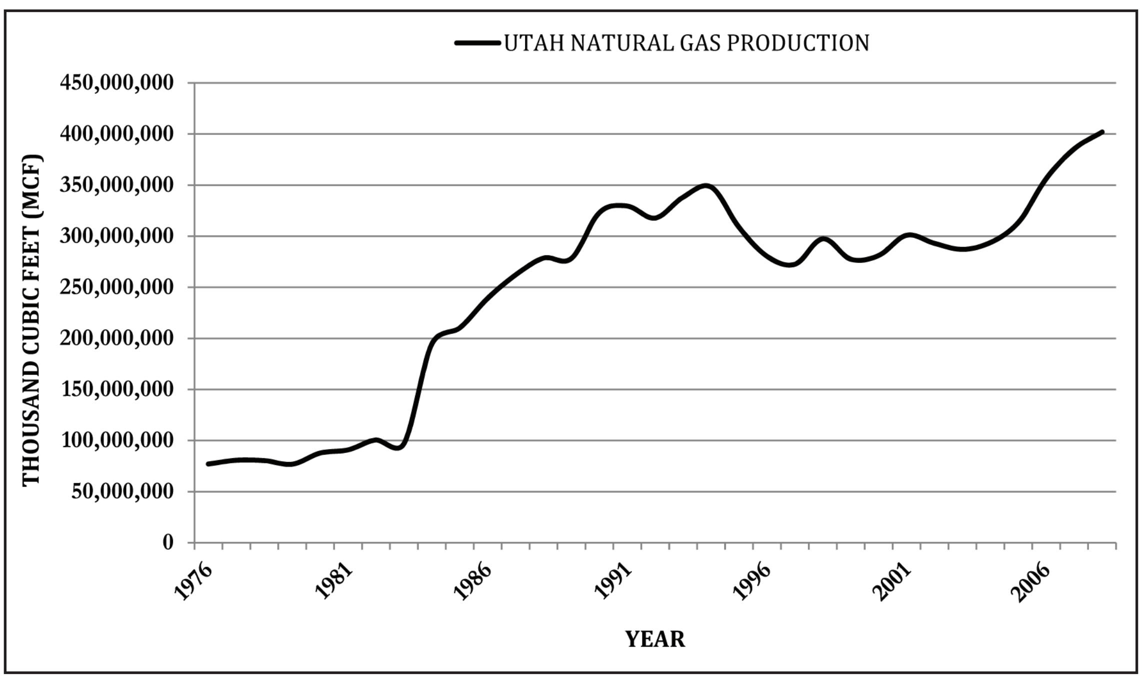


Figure 8.6.3. Natural gas production in Utah from 1976 to 2008.
Source: Utah Geological Survey (UGS).

Natural gas is more of a regional commodity than crude oil, with more dependence on local supply and demand factors. The necessity of transporting natural gas by pipeline is affected by availability of transportation infrastructure, which has a large influence on natural gas prices. Currently, there is a shortage of pipeline capacity in the Rocky Mountains, and wellhead natural gas prices in the area are depressed compared to the rest of the country (UGOPB, 2009).

Coal Production – Coal is a combustible, sedimentary rock that was formed approximately 3 million years ago. Organic remains, specifically plants, were protected by water and soil against oxidation and biodegration; therefore, carbon was trapped in the ground. Through time, the chemical and physical properties of carbon were changed by thermal and geological processes to create a solid material (UMA, 2009).

Coal prospecting and mining began in the 1850s and has been an important part of the Utah economy since the 1890s. By the 1950s, oil and natural gas largely replaced coal as the chief home-heating fuel and for industrial purposes. However, between 1970 and 1983, Utah coal production doubled as oil prices increased. Many electrical power plants were converted from oil to coal at this time (UGS, 2009a). Ninety-two percent of all coal produced is used to generate electricity, which provides approximately half of all the electricity used in the United States. In Utah, coal generates about 82 percent of all electricity; generating this electricity consumes 60 percent of the total coal produced in Utah. Utah coal is desirable because of its high-BTU (British thermal unit), low-sulfur, and low-ash content. The demand for coal is expected to rise, given population growth and increasing demand for electricity (Newell et al., 2008).

Coal production in Utah increased through the 1980s and 1990s, reaching an all-time high of 27 million short tons in 1996. Utah coal production was 24.3 million short tons in 2008 (Figure 8.6.4). Currently, all coal in Utah is mined from the Wasatch Plateau, Book Cliffs, and Emery coal fields in central Utah (Figure 8.6.5). The greatest revenue from coal was realized in 1982, at more than $1 billion (inflation adjusted). Today, approximately 64 percent of coal produced in Utah is distributed within the state, with the majority of it going to electric utilities. The average price for electricity in Utah is the fifth lowest in the nation, largely because of the abundant supply of coal (UGS, 2009a).

Oil Shale and Tar Sands – Oil shale and tar sands are two natural resources that can be converted into petroleum products. Utah contains some of the largest deposits in the world of both of these materials. It is estimated that the United States reserves of oil shale are 1.6 tril-

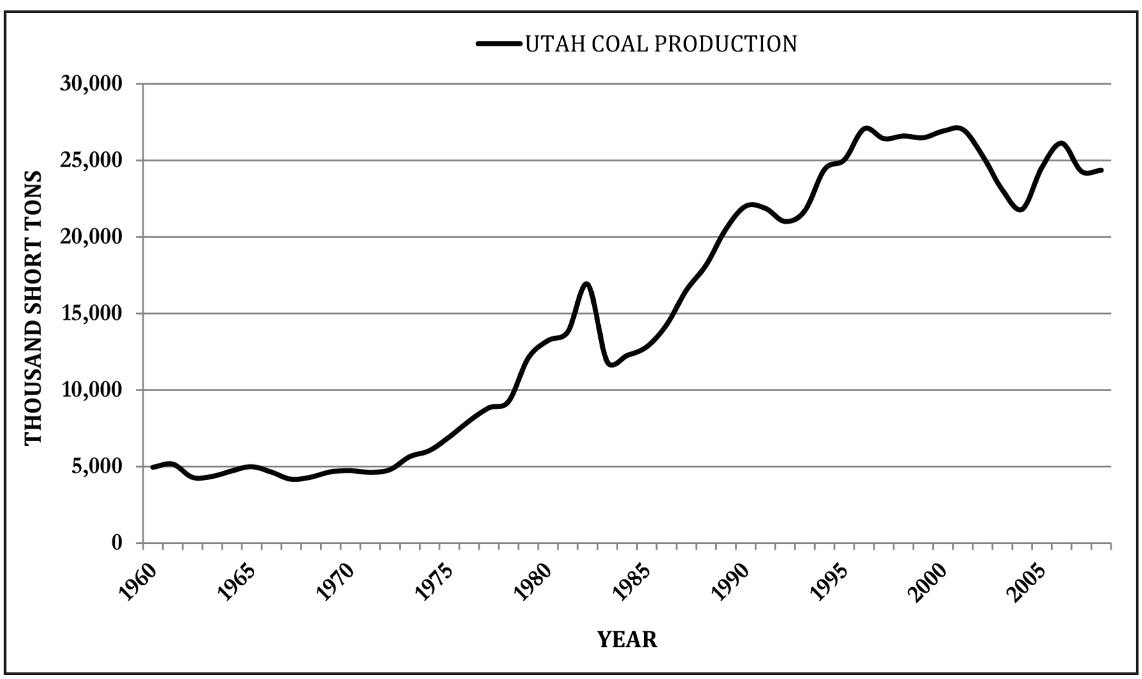


Figure 8.6.4. Coal production in Utah from 1960 to 2008.
Source: Utah Geological Survey (UGS).

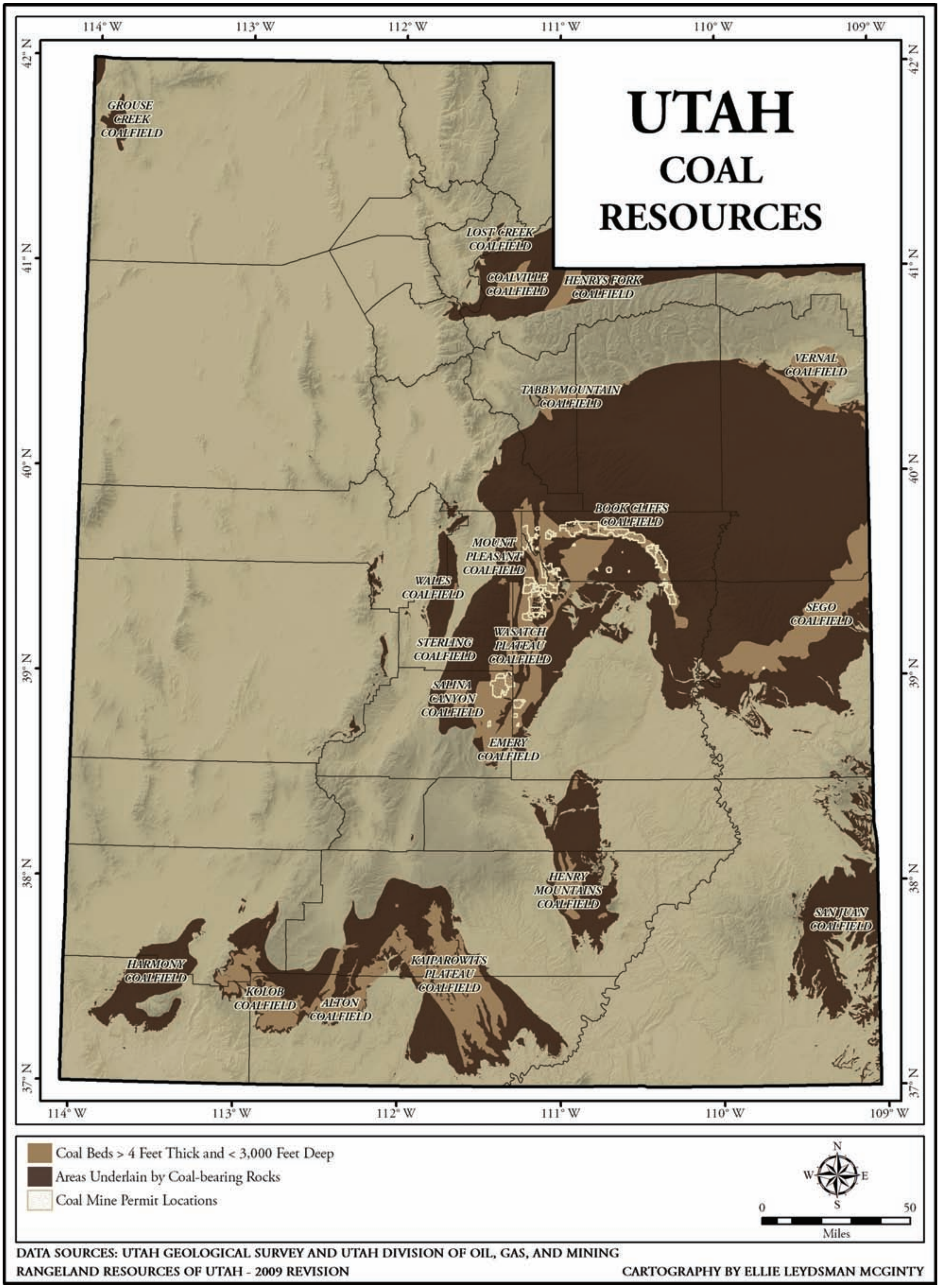


Figure 8.6.5. Coal resources and coal mine permit locations in Utah.

lion barrels, with Utah reserves at approximately 499 billion barrels (Tabet, 2006). The United States estimate for measured reserves of tar sands is 22.6 billion barrels, with 14 to 15 billion barrels of measured reserves in Utah (Gwynn, 2007). The problems facing the development of these resources include environmental damage from the extraction, production, and use of the material, as well as financial, technological, and ownership issues. These oil substitutes become more financially-viable resources as the price of traditional oil goes up (Newell et al., 2008).

The Utah Governor's Office is working with local stakeholders and policymakers, as well as the federal government, in preparing for the eventual development of oil shale and/or tar sands in Utah. Recently, the environmental assessment for a 60-acre research, development, and demonstration (RD&D) lease of the White River oil shale mine on federal lands in eastern Utah has been completed by the Bureau of Land Management. The Governor's Office is monitoring the data as it becomes available from research and development projects, and the state will work with stakeholders to formulate responsible development policies (UEO, 2009).

RENEWABLE ENERGY RESOURCES

Geothermal Power Generation – Exploitable geothermal resources come from the transport of heat to the surface through several geological and hydrological processes. Geothermal resources commonly have three components: 1) a heat source, 2) relatively high permeability reservoir rock, and 3) water to transfer the heat. Numerous high-temperature resources occur in the Basin and Range Province of the western United States as the result of deep circulation along major faults in a region of high heat flow (Figure 8.6.6). Utah has high-temperature resources that are suitable for electricity generation, as well as direct use and heat pump applications, and is one of only four states with geothermal electric power plants (UGS, 2009c).

More than 15 years ago, Phillips Petroleum and Utah Power teamed to build the Blundell Plant, the first geothermal electric plant outside of California. The hydrothermal reservoir at Blundell lies 3,000 feet below the Earth's surface and contains water at more than 500 degrees Fahrenheit and a pressure of 500 pounds per square inch. There are currently three geothermal power plants in operation in Beaver County, Utah: Blundell Units 1 and 2 and Thermo Hot Springs. Unit 1 of the Blundell Plant has a gross capacity of 25 megawatts, Unit 2 has a capacity of 11 megawatts, and Thermo Hot Springs has a net capacity of 10 megawatts. Electric power has been generated at the Cove Fort-Sulphurdale Known Geothermal Resource Area (KGRA), also in Beaver County. In 2003 and 2004, the Cove Fort-Sulphurdale units were shut down for modernization. Utah currently has five projects in various stages of development that would supply 234 megawatts of electricity (US DOE, 2008; Slack, 2008; UGS, 2009b; UGS, 2009c; Nielson et al., 2006).

Solar Power Generation – The Renewable Energy Atlas of the West (Nielsen et al., 2006) estimated the annual solar electricity generation potential in Utah to be 69 billion kWh (kilowatt-hours), based on the following assumptions: 1) rooftop and open space installed systems represent 0.5 percent of the total area of the state, 2) solar panels occupy 30 percent of the area set aside for solar equipment, and 3) the average system efficiency is 10 percent.

Different collector types use the sun in different ways. Concentrating collectors, collectors that focus the sun (like a magnifying glass), can reach high temperatures and efficiencies and only use direct rays from the sun. Flat panel collectors are mounted on rooftops or on the ground and are stationary. These collectors can use both the direct rays and reflected light. They use all available sunlight and are the best choice for many northern states. For flat-plate collectors, Utah has very good solar resources. For concentrating collectors, Utah has good resources throughout the state with the best resources falling in the southern region of the state (US DOE, 2008) (Figure 8.6.7).

Wind Power Generation – The United States Department of Energy (2008) reports that Utah has wind resources that will support utility-scale production. Large contiguous areas of high-quality wind energy resources are located in western Utah, especially near the Raft River Mountains in Box Elder County near the Idaho border, and in the area near Milford in Beaver and Millard counties. Other good wind resource areas are located on the higher ridge crests throughout the state (Figure 8.6.8). In addition, small wind turbines may have applications in some areas. As a renewable resource, wind is classified according to wind power classes, which are based on typical wind speeds. These classes range from Class 1 (the lowest) to Class 7 (the highest). In general, Class 4 or higher (greater than 15.7 miles per hour) can be useful for generating wind power with large turbines.

The Renewable Energy Atlas of the West (Nielson et al., 2006) estimated the annual wind electricity generation potential in Utah to be 23 billion kilowatt hours. The es-

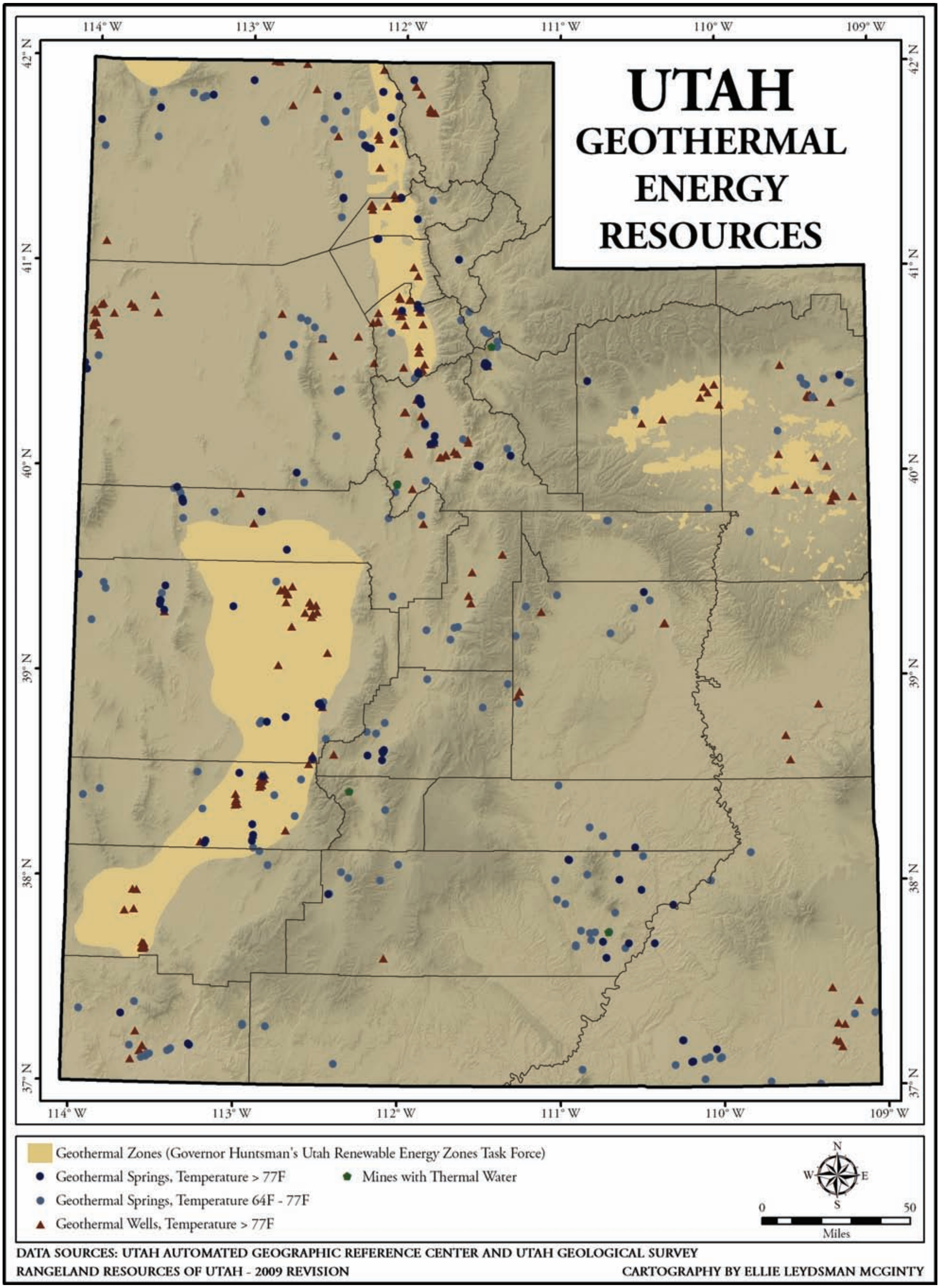


Figure 8.6.6. Geothermal zones, springs, and wells in Utah.

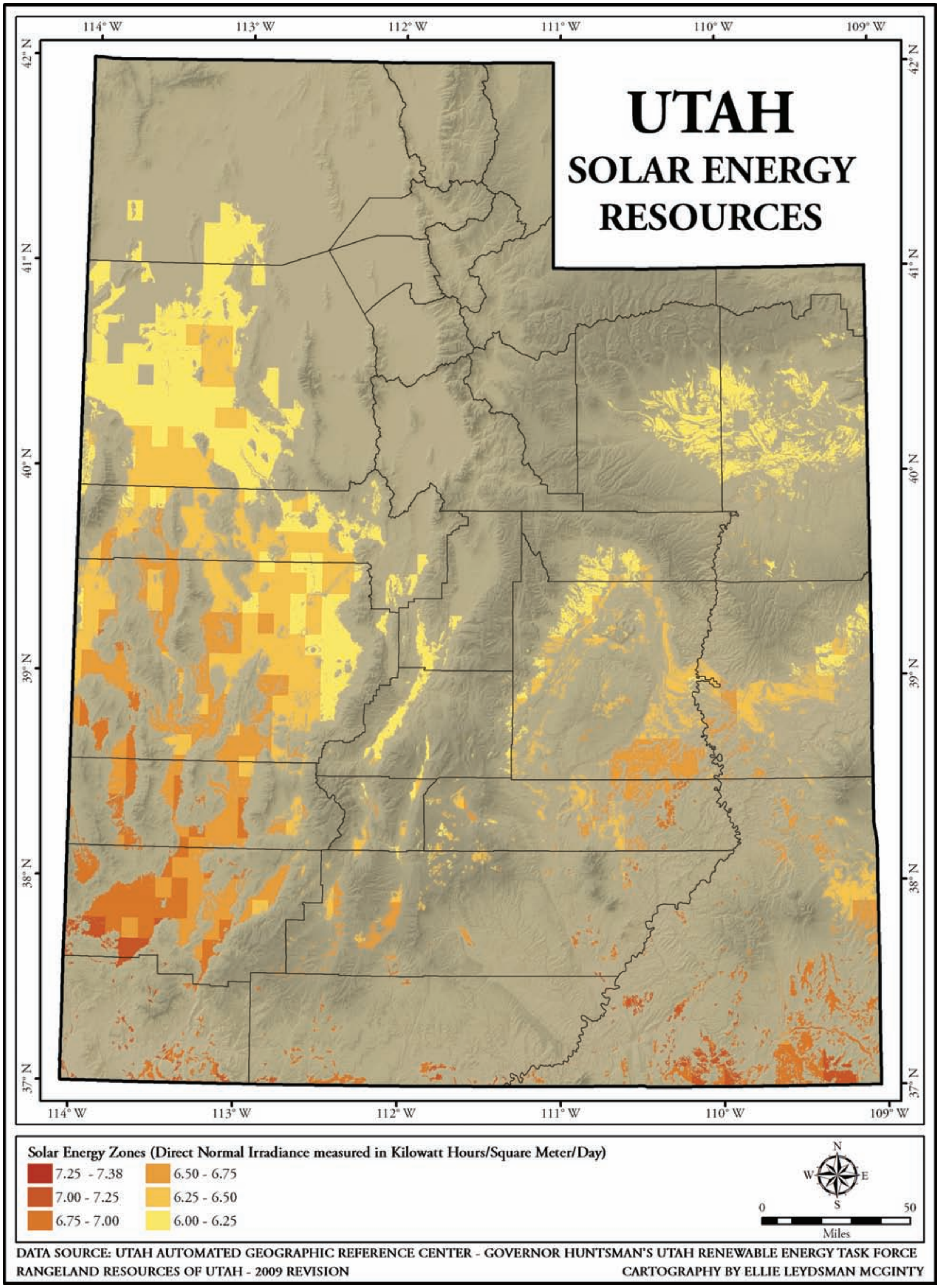


Figure 8.6.7. Solar energy resources in Utah.

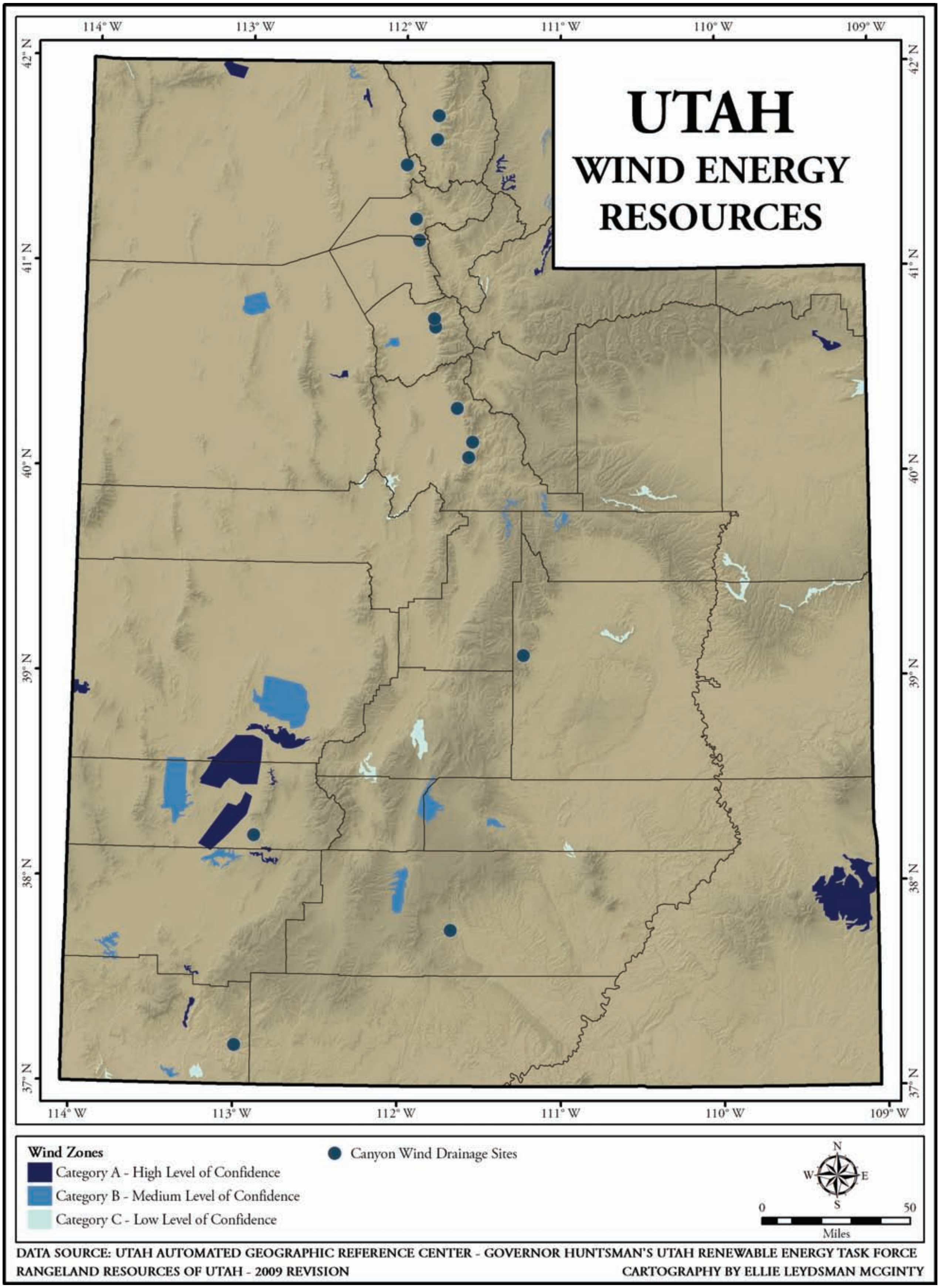


Figure 8.6.8. Wind energy resources in Utah.

timate excludes the following areas, which are assumed to be infeasible for wind development: 1) federally classified sensitive land – 100 percent excluded, 2) forest – 50 percent excluded, 3) agriculture – 30 percent excluded, 4) range – 10 percent excluded, and 5) mixed agriculture and range – 20 percent excluded. The feasibility of developing wind for electricity is contingent on a number of issues, including sufficient wind resource, transmission access, location approval, avian issues, aesthetics, and local community support (Mongha et al., 2006).

Commercial-scale wind energy is now included in the electric generation portfolio of Utah. The first commercial wind farm at the mouth of Spanish Fork Canyon began generating electricity in late 2008 (UGOPB, 2009). This farm consists of nine 2.1-megawatt turbines, providing a total capacity of 18.9 megawatts. In addition, construction is underway just north of Milford, Utah, for a 200-megawatt wind farm that will contain 97 2.1-megawatt turbines. In January 2009, the Utah School and Institutional Trust Lands Administration (SITLA) issued its first lease for the development of wind energy resources on state trust lands. The 1,560-acre lease was issued to a subsidiary of the developer of the 200-megawatt Milford Wind Project in Beaver and Millard counties. SITLA anticipates the lessee will locate approximately 11 wind turbine generators of up to 2.5 megawatts each on trust lands, depending on final engineering and turbine availability. The lessee will pay land rentals, plus additional payments based on the capacity of turbines located on state trust lands (Hebertson and McMichael, 2009).

Hydroelectric Power Generation – There are 92 hydroelectric power plants with a combined total electricity generation capacity of 276.5 megawatts in Utah. Hydroelectric power plants capture the kinetic energy of water to generate electricity. A turbine and a generator convert the kinetic energy to electrical energy. These hydroelectric plants vary by ownership (municipal, commercial, cooperative, and federal) and size and are located on various streams and rivers around the state (UGS, 2009d).

Biomass Power Generation – The Renewable Energy Atlas of the West (Nielsen et al., 2006) estimated the electricity-generating potential from landfill gas and animal waste to be 1 million megawatt hours per year. Currently, there are five power plants in Salt Lake and Davis counties utilizing municipal waste or landfill gas as the power source for generating electricity. The combined capacity of these five plants is 4.4 megawatts (UGS, 2009e).

NUCLEAR ENERGY RESOURCES

Nuclear power is a source of energy derived from the fission (splitting) of atoms. It accounts for approximately 19 percent of total electricity generated in the United States. Utah neither generates nor imports power from nuclear power plants. By-products of nuclear energy are cleaner than those produced by burning fossil fuels for power (near-zero emissions of carbon dioxide, sulfur oxides, nitrogen oxides, and ash), but it does produce solid waste by-products that must be stored. While these waste products are small compared to the electricity produced, they require specific safety measures. There has been discussion of building a plant in Utah. An operator is expected to submit an application to the United States Nuclear Regulatory Commission in 2010 for a new nuclear power plant. The estimated construction costs of building such a plant in Utah are as high as $2 to 3 billion (Newell et al., 2008).

More than 300,000 pounds of U_3O_8 (uranium/yellow cake), valued at approximately $26 million, were produced from three Utah mines in 2008. The first year that uranium production values have been reported since 1997 was in 2008. The reactivation of the uranium mines is largely the result of a three-fold increase in yellow cake prices that peaked in 2007. Spot uranium prices declined by about 50 percent in 2008, resulting in one mine closure. This price drop may delay or preclude the planned opening of several mines and the reopening of the Ticaboo Uranium Mill (UGOPB, 2009; Bon and Krahulec, 2008).

ISSUES AFFECTING THE UTAH MINING INDUSTRY

Significant short-term issues expected to impact the mineral industry in Utah include the availability of capital to fund exploration and development of new mineral resources, conflicts in commodity leasing (for example, oil and gas versus potash), permitting delays, and the decreased incentive to explore for metal and mineral commodities in a declining price environment. Long-term issues include the change in rural Utah from a resource-based to a tourism-based economy that will continue to have a significant long-range impact on the availability of lands open for exploration, and the willingness of the public to accept mineral development in areas they consider environmentally sensitive (UGOPB, 2009).

URBANIZATION IN UTAH

Ellie I. Leydsman McGinty

In past decades, declining profitability of cattle ranching on both public and private land appeared to represent the greatest threat to livestock grazing. However, recent studies suggest that urbanization, accompanied with a shrinking land base, presents the gravest threat to western ranching. Additionally, other challenges to the western livestock industry, such as extensive invasion by non-native plants and an escalating concern over endangered species, are intensified by urbanization (Sheridan, 2007; Holechek, 2001).

Conservative estimates indicate that 3 to 4 million acres of private rangeland in the western United States have been converted to suburban developments and ranchettes (Holechek, 2001; Resnik et al., 2006). Since World War II, the western United States has changed from a rural society dominated by agriculture, livestock grazing, mining, and logging, to a society characterized by urban, suburban, and exurban growth. Beginning in the 1970s, a transformation of the land market was initiated. Farmland and rangelands began to be valued in terms of their real estate potential rather than their value as cropland and pastureland (Sheridan, 2007).

The rise of suburban growth has been attributed to post-World War II policy changes during the 1940s. Mortgage insurance and loan programs under the Federal Housing Authority and the Veterans Administration provided low-interest mortgages with minimal to no down-payments for first-time home buyers and returning veterans. Funding for the construction of interstate highways under the Interstate and Defense Highway Act of 1956 and low federal tax rates on automobile fuel contributed to the expansion of single-family dwellings in the suburbs (Williams, 2000; Soule, 2006). Floodplain insurance also contributed to the construction of homes in outlying areas (Burchell et al., 2005). Growing populations, rising incomes, falling commuting costs, and failures to account for the benefits of open space and the costs of infrastructure have contributed to suburban growth that has displaced valuable agricultural land (Brueckner, 2000; Kotval and Mullin, 2006).

Continued suburban and exurban growth in the western United States has been promoted by two primary circumstances. First, improved communication and technology, rising affluence, and demographic shifts have increased the demand for residential real estate and elevated the value of private rangeland property in the Intermountain West. Second, the profitability of agricultural industries continues to decline, particularly in arid public land ranches, as a result of rising production costs, such as insurance, electricity, taxes, livestock health care, transportation, supplemental feeding costs, and state and private lease grazing fees (Holechek, 2001; Holechek and Hawkes, 2007; Workman and Evans, 1993).

As a result of these two situations, ranchers and farmers may increasingly view selling land to developers as a viable alternative or as an inevitable option to intergenerational inheritance (Gosnell and Travis, 2005). When a decision is made by a rancher or farmer to sell property, a cascading effect of land transformation is instigated. The decision of a single ranch or farm owner to sell land may, in fact, determine the fate of many thousand acres. Landowner decisions affect more than their own property. One decision can weaken the agricultural infrastructure, change the land values, and create new growth nodes (Liffman et al., 2000). Livestock producers who wish to remain in production may not be able to lease sufficient land to supplement their deeded land, and they may not remain financially viable. Consequently, they may succumb to development pressure (Resnik et al., 2006).

The rapid rate of land transformation, accompanied by urban, suburban, and exurban growth, is coupled with large-scale rangeland and farmland fragmentation. Land fragmentation adversely affects the efficiency and productivity of agricultural operations. Some studies have indicated that for every 1 acre lost to subdivisions, another 3 to 10 acres may be lost from the ranching land base due to fragmentation (Holechek, 2001). The repercussions of unregulated growth and land fragmentation include declining agricultural commodities, suppression of rural economies, displacement of wildlife habitat, elimination of recreational opportunities, and rising land prices.

In addition to the direct loss and fragmentation of private rangeland and farmland, the unregulated patterns of urbanization in the Intermountain West pose several indirect social and economic problems to ranchers and farmers. Typically, as suburbanization extends into rural areas, agricultural and nonagricultural land-use conflicts become more severe. Increases in non-farm population in rural and semi-rural areas introduce a number of factors that may undermine the agricultural establishments (Lopez et al., 1988).

Ranching and farming activities that are deemed nuisances by new suburban residents, such as burning and weed control, may be legislated against. Property taxes, which are substantially incurred by ranchers and farmers who own vast tracts of land, may be increased to pay for new schools, roads, and utilities. The costs of infrastructure, such as roads, electricity, sewage, water, and telecommunication, for low density housing are typically two to four times more than those associated with higher density housing within city or town perimeters. The principle of eminent domain may be imposed by governments to acquire ranchland and farmland for public uses aimed at serving the new suburban population. Trespassing, vandalism, and loss of livestock from theft and vehicle accidents may increase as development extends beyond the urban fringe (Berry, 1978; Holechek, 2001).

In Utah, the land in farms, including harvested cropland and pastureland, declined by 2.5 million acres, or 18 percent, from 1960 to 2008 (NASS, 2009). Although urbanization may not be the sole cause of this decrease in Utah, it has undeniably contributed to the trend. Since Mormon settlers entered the Salt Lake Valley in 1847, the population has steadily grown. With the exception of the Great Depression and the recession in the late 1980s, the average growth rate in Utah since 1900 has been about 2.5 percent per decade. In 1900, the population of Utah was 276,749; in 1950, the population was 688,862; and in 2000, the population was 2,233,169. The estimated population of Utah in 2008 was 2,736,424. The population has long been concentrated along the Wasatch Front; however, the Wasatch back valleys and southern Utah are experiencing some of the highest rates of growth. As of 2008, the five most populated counties in Utah were Salt Lake County with a population of 1,009,518; Utah County at 483,702; Davis County at 288,146; Weber County at 221,846; and Washington County at 133,791 (Figure 8.7.1). The five fastest growing counties, given the rates of change from the 1990 Census to the 2007 Census estimates, were Washington, Summit, Iron, Tooele, and Wasatch counties (Figure 8.7.2).

Many state and local government agencies are beginning to implement solutions that counter this trend of land transformation. Tax-based funds are being developed, such as the State of Utah LeRay McAllister Critical Land Conservation Fund, to preserve critical lands, such as farmland, ranchland, wildlife habitat, and culturally and historically significant landscapes, from future development. Tax-based revenues are often used to purchase conservation easements. Conservation easements are legal agreements between private landowners and land trusts or government agencies that extinguish the development rights in order to protect the valuable resources on the property. The property remains in the possession of the original landowner and most private property rights are retained. The easement is held by a land trust, such as The Nature Conservancy, or a government agency, such as the Utah Department of Natural Resources or Utah Department of Agriculture and Food (UGOPB, 2008).

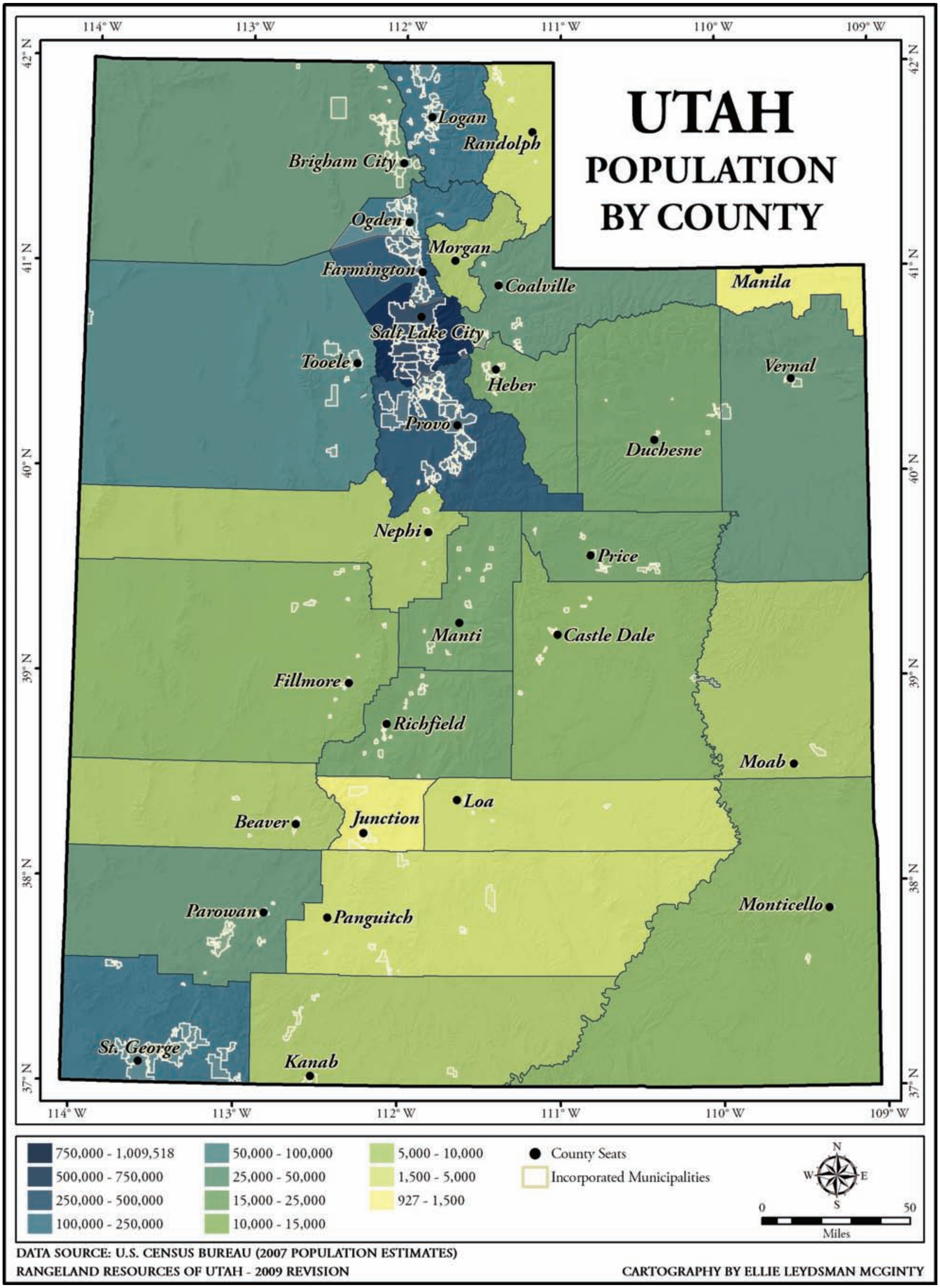


Figure 8.7.1. Populations of Utah counties.

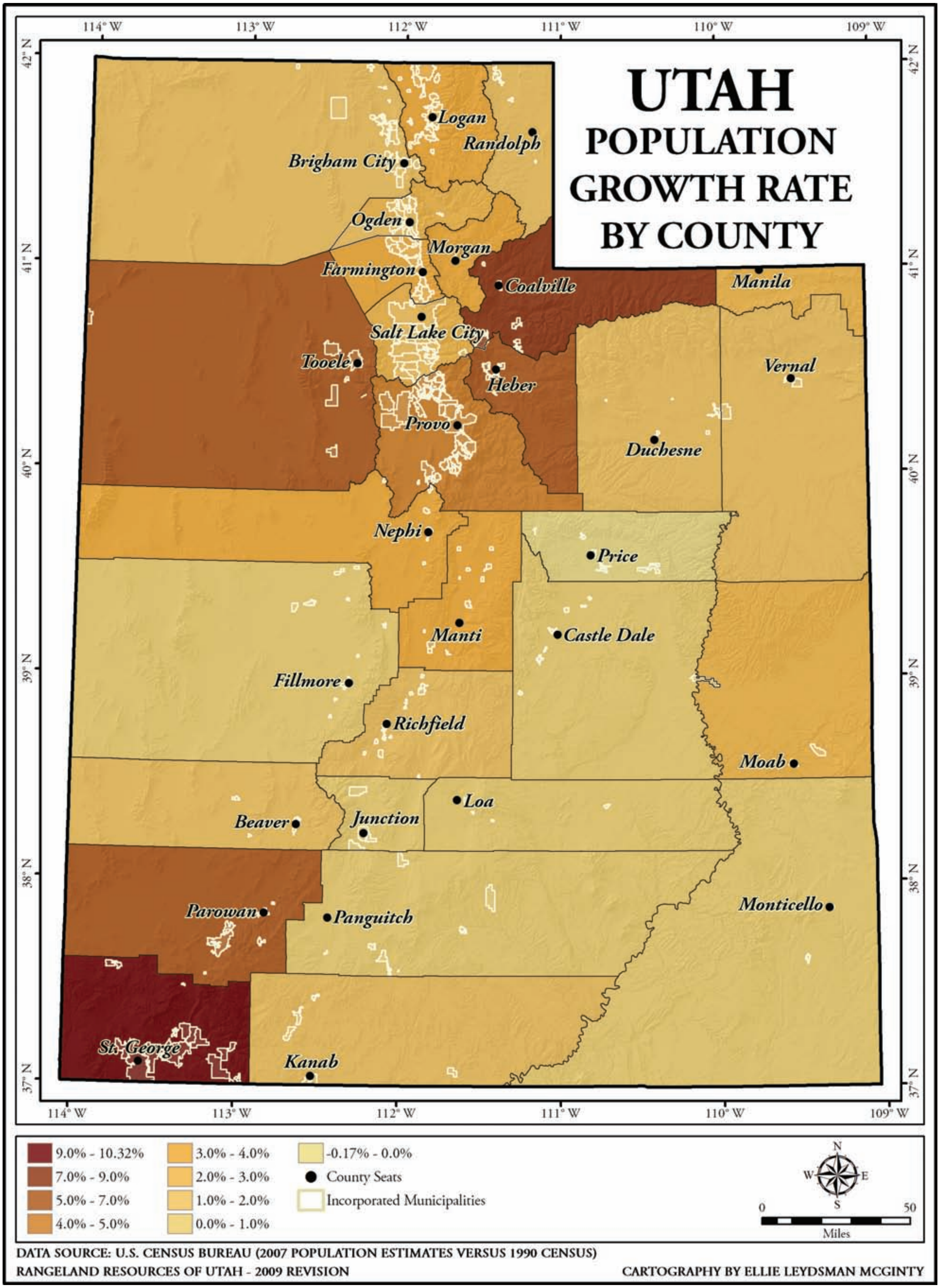


Figure 8.7.2. Population growth rates of Utah counties.

Rangeland Management Initiatives

Ellie I. Leydsman McGinty
Roger E. Banner

In response to some of the institutional, environmental, social, and economic problems facing the western livestock industry, several national, state, and local agencies and organizations have developed management initiatives and programs to enhance rangeland sustainability. Sustainable rangeland management integrates three primary objectives, including environmental health, economic profitability, and social responsibility. Additionally, the Sustainable Rangelands Roundtable (SRR) defines rangeland sustainability as the capacity of rangelands to maintain health, productivity, diversity, and overall integrity from generation to generation, in the context of ecological, social, and economic systems.

The Sustainable Rangelands Roundtable is a partnership of about 50 organizations, including federal land management and research agencies; tribal, state, and local governments; scientific societies; non-governmental organizations; and researchers. The partnership has identified a set of five criteria embodying social, economic, and ecological factors for assessing rangeland sustainability. The five core criteria include: (1) conservation and maintenance of soil and water resources, (2) maintenance and conservation of plant and animal resources on rangelands, (3) maintenance of productive capacity on rangelands, (4) maintenance and enhancement of multiple economic and social benefits to current and future generations, and (5) development and promotion of legal, institutional, and economic frameworks for rangeland conservation and sustainable management (SRR, 2005).

These five components of rangeland sustainability have been instrumental in guiding and enhancing management programs within the nation, individual states, and local entities. The Utah Partners for Conservation and Development, the Utah Department of Natural Resources, the Utah Department of Agriculture and Food, the USDA Natural Resources Conservation Service, the USDA Sustainable Agriculture Research and Education program, the Bureau of Land Management, and the Utah Quality Growth Commission are some of the federal and state agencies and organizations that have coordinated with ranchers and farmers in Utah to improve rangeland sustainability. Additionally, the Utah Farm Bureau Federation, the Utah Cattlemen's Association, and the Utah Wool Growers Association are some local organizations that support the local agricultural industry and endorse the adoption of good livestock production practices.

UTAH PARTNERS FOR CONSERVATION AND DEVELOPMENT

Utah Partners for Conservation and Development (UPCD) is a partnership of 17 natural resource-oriented state and federal agencies and organizations committed to providing solutions to conservation issues. The core values of the coalition are to protect biological diversity; to preserve water quality and quantity for municipal, agricultural, and natural resource uses; to promote sustainable agriculture through working and productive farms and ranches; and to support outdoor recreation opportunities, access, and quality. The premise of the partnership is to foster collaboration in order to increase the effectiveness of sustainable conservation solutions at local levels (UPCD, 2009).

Utah Partners for Conservation and Development administers the Utah Watershed Restoration Initiative, with the Utah Department of Natural Resources serving as the implementing agency. The Utah Watershed Restoration Initiative (UWRI) is a partnership-driven effort to conserve, restore, and manage ecosystems in priority areas across the state of Utah in response to invasion of exotic species and pathogens, increased frequency and intensity of wildfire, conversion of productive habitat to undesirable species, land fragmentation, and habitat loss. Utah Partners for Conservation and Development has three general approaches for addressing watershed and ecosystem issues. The first approach entails ecosystem restoration through physical and mechanical habitat manipulations, such as seeding, vegetation management, and species transplant. The second approach includes changes in land management, which may be made through permitted or allowed uses and management prescriptions. The third approach consists of increasing communication and team building among the public, stakeholders, and involved agencies (UWRI, 2009).

UTAH DEPARTMENT OF NATURAL RESOURCES PROGRAMS

The Landowner Incentive Program (LIP) is a voluntary program managed by the Utah Division of Wildlife Resources (UDWR) and the Natural Resources Conservation Service. The program provides technical and financial assistance to private landowners for the protection and management of habitat to benefit federally listed, proposed, candidate, or other at-risk species on private lands. The Utah Division of Wildlife Resources has identified two primary areas of focus for the Landowner Incentive Program in Utah, including (1) sagebrush steppe uplands supporting sage grouse species, sharp-tailed grouse, neotropical migratory bird species, pygmy rabbit, and prairie dog species, and (2) low- to mid-elevation riparian corridors and wetlands supporting various trout species and at-risk neotropical migratory bird species (NRCS, 2005).

The Forest Legacy Program (FLP) is a conservation easement program operated by the Utah Division of Forestry, Fire, and State Lands (UDFFSL) and funded by the United States Forest Service (USFS). The program is designed to protect environmentally important forests and to prevent future conversions of forest land and resources. Conservation easements are used to achieve the objectives of protecting and enhancing water quality; protecting wildlife habitat and maintaining habitat connectivity; maintaining and restoring riparian areas; maintaining forest sustainability; and sustaining the cultural and economic vitality of rural communities. Accompanied with the conservation easement is a management plan or stewardship plan. The plans are specifically tailored to each property and are written to encourage long-term stewardship (UDFFSL, 2008; USFS, 2006).

UTAH DEPARTMENT OF AGRICULTURE AND FOOD PROGRAMS

The Utah Department of Agriculture and Food (UDAF) is a state agency that promotes and protects the interests and products of agriculture and related industries. The agency oversees the Division of Grazing Improvement and administers the Grazing Improvement Program (GIP). The Grazing Improvement Program is a broad-based, voluntary program, led by range specialists and assisted by policy analysts and rangeland scientists. It is focused on improving the productivity and sustainability of Utah rangelands and watersheds. Cost-share grants are awarded to applicants in five regions (Northeast, Northwest, Central, Southeast, and Southwest) in Utah to improve grazing management practices and rangeland resource health on private and public land. The Grazing Improvement Program has approved funds to increase livestock water supplies, improve grass species that benefit livestock and wildlife, combat forage-damaging insects, and rehabilitate rangeland damaged by wildfire (UDAF, 2007).

The Utah Department of Agriculture and Food, in collaboration with the Utah Partners for Conservation and Development, secured support from the Utah Legislature for the war on cheatgrass. Senate Bill 89, authored by Senator Dennis Stowell, established the Invasive Species Mitigation Fund and set aside $2 million to fund range projects that will limit the size and frequency of wildfires. A significant portion of Utah rangeland is being invaded by fast- growing annual grasses, such as cheatgrass, that negatively impact livestock grazing and wildlife habitat. Cheatgrass has been blamed for fueling catastrophic fires during the summer of 2007 that contributed to highway traffic fatalities and record pollution in Utah. Provisions of Senate Bill 89 offer the UDAF and UPCD the financial resources to undertake projects to reduce cheatgrass encroachment. The UDAF and associated partners distributed $2 million from the Invasive Species Mitigation Fund in 2008 for ten projects affecting 705,000 acres in nine counties. These projects were undertaken by agencies such as the BLM, the Department of Natural Resources, the Utah Conservation Commission, and 15 other state and federal agencies. The projects will focus on mitigating risks to public safety and health, air pollution, flooding, soil erosion, the release of carbon, damage to local economies, and habitat for wildlife or livestock (UDAF, 2008).

The Utah Department of Agriculture and Food also supervises the Utah Conservation Commission (UCC). The Utah Conservation Commission, authorized under the Utah Conservation Commission Act and comprised of a 16-person board, aspires to preserve the soil and water resources in Utah. Since 1937, the commission has been actively involved in planning and cultivating programs that ensure the development and utilization of soil and water resources, while protecting them from the adverse effects of wind and water erosion and sediment-related pollutants (UDAF, 2009).

NATURAL RESOURCES CONSERVATION SERVICE PROGRAMS

The USDA Natural Resources Conservation Service (NRCS) offers several technical assistance, incentive-based, and easement programs to ranchers, including the Environmental Quality Incentives Program (EQIP), the Grazing Land Conservation Initiative (GLCI), Wildlife Habitat Incentives Program (WHIP), Agricultural Management Assistance (AMA) program, and the Farm and Ranch Lands Protection Program (FRPP).

The Environmental Quality Incentives Program (EQIP) is a voluntary conservation program that provides assistance to landowners and agricultural producers in a manner that promotes agricultural production and environmental quality as compatible goals. Through the program, farmers and ranchers receive financial and technical assistance to implement structural and management conservation practices that optimize environmental benefits on working agricultural land. The NRCS provides funding and expertise for measures to protect natural resources, while ensuring sustainable production on farms, ranches, and working forest lands.

The Grazing Land Conservation Initiative (GLCI) program is a voluntary program whereby the Natural Resources Conservation Service provides technical assistance to owners and managers of private grazing land. Although the program does not provide financial or cost-share assistance, the program offers opportunities to maintain and improve private grazing land by implementing grazing land management technologies that protect and improve water quality, maintain and improve wildlife and fish habitat, enhance recreational opportunities, encourage diversification, and promote the use of sustainable grazing systems (NRCS, 2003).

The Wildlife Habitat Improvement Program (WHIP) is a voluntary program that encourages the improvement of high-quality wildlife habitat on private property. The Natural Resources Conservation Service provides technical and financial assistance to landowners that enhance upland, wetland, riparian, and/or aquatic habitats on private property. Through the program, the Natural Resources Conservation Service works with participants to develop a wildlife habitat plan. The plan becomes the basis of the cost-share agreement between the agency and the landowner (NRCS, 2004a).

The Agricultural Management Assistance (AMA) program provides cost-share assistance and incentive payments to agricultural producers who voluntarily address issues, such as water quality and soil erosion control, by incorporating conservation practices into their operations. The Agricultural Management Assistance program is available in 15 states, including Utah. Under the program, the Natural Resources Conservation Service works with landowners to develop conservation plans. The conservation plans provide the foundation for the contract between the agency and the landowner (NRCS, 2007).

The Farm and Ranch Lands Protection Program (FRPP) is a voluntary program that provides matching funds to organizations with existing farm and ranch land protection programs to purchase development rights and conservation easements to preserve productive farm and ranchland (NRCS, 2004b). Conservation easements are legal agreements between a private landowner and a land trust or government agency that prohibits development on the land in order to protect the ecological or cultural value. The conservation easement is either voluntarily donated or sold by the landowner. The property remains in the possession of the original landowner and most private property rights are retained. The easement is held by a land trust, such as The Nature Conservancy, or a government agency, such as the Utah Department of Natural Resources or Utah Department of Agriculture and Food. The easement holder extinguishes the development rights in order to protect the valuable resources on the property (UGOPB, 2008).

USDA SUSTAINABLE AGRICULTURE RESEARCH AND EDUCATION PROGRAM

Since 1988, the USDA Sustainable Agriculture Research and Education (SARE) program has helped advance farming and ranching systems that are more sustainable by administering competitive research and education grant programs. The grants are offered through four regions, including North Central, Northeast, South, and West, under the direction of councils that consist of farmers, ranchers, representatives from universities, government agencies, agribusinesses, and non-profit organizations. The grants are used to increase knowledge about sustainable agricultural practices and to help farmers and ranchers adopt innovative systems. The Western SARE program, hosted by Utah State University, administers grants in several categories, such as Research and Education grants, Farmer/Rancher grants, Professional/Producer grants, and Professional Development grants (USDA SARE, 2008).

BUREAU OF LAND MANAGEMENT

In 2007, Secretary of the Interior Dirk Kempthorne launched the Healthy Lands Initiative to accelerate land restoration, to increase productivity, and to improve the health of public lands in seven western states, including: Utah, Wyoming, New Mexico, Oregon, Idaho, Nevada, and Colorado. The primary objective of the initiative is to preserve the diversity and productivity of public and private lands, with an emphasis on improving critical sage grouse habitat and other important wildlife habitat in the wildlife-energy interface. In 2008, the budget for the initiative was $22 million. The 2009 budget included an increase of $10 million over the level enacted in the 2008 fiscal year.

In Utah, the Bureau of Land Management, in cooperation with the Utah Partners for Conservation and Development, is using funds from the Healthy Lands Initiative in conjunction with the Utah Watershed Restoration Initiative to conduct efficient science-based monitoring and restoration activities; to increase water quality and quantity on rangeland; to promote sustainable working farms and ranches; and to encourage social-economic uses and opportunities. The additional funds from the 2009 fiscal year will permit an increased number of land treatments, facilitate best-management practices, and update habitat management plans based on new information and technology (BLM, 2008).

UTAH QUALITY GROWTH COMMISSION

The Utah Quality Growth Commission (UQGC) was established in 1999 by the Quality Growth Act in order to address the challenges and opportunities associated with population growth. The Commission has three primary responsibilities: (1) to provide local governments with planning assistance, (2) to recommend principles of quality growth and advise the legislature on growth management issues, and (3) to administer the LeRay McAllister Critical Land Conservation Fund. The LeRay McAllister Critical Land Conservation Fund is an incentive program that provides grants and loans to preserve or restore critical lands, such as agricultural lands, wildlife habitat, and culturally and historically significant landscapes (UGOPB, 2008; UQGC, 2008).

The program has been influential in preserving large expanses of private ranchland via the purchase of conservation easements. The LeRay McAllister Fund provides up to 50 percent of the project cost, but applicants must provide the remaining 50 percent or more of matching funds. Matching funds typically come from private citizens, conservation foundations, government agencies, the Utah Department of Agriculture and Food, the Utah Department of Natural Resources, and/or the Natural Resources Conservation Service Farm and Ranch Lands Protection Program (UGOPB, 2008; UQGC, 2008).

References

Adams, M. B., L. Loughry, and L. Plaugher. 2004. Experimental Forests and Ranges of the UDSA Forest Service. USDA Forest Service General Technical Report NE-321. Northeastern Research Station, Parsons, WV.

Alexander, T. G. 1987. From rule of thumb to scientific range management: the case of the Intermountain Region of the Forest Service. The Western Historical Quarterly 18(4): 409-428.

Alexander, T. G. 1996. Utah, The Right Place: The Official Centennial History. Gibbs Smith Publishers. Salt Lake City, UT.

Alexander, T. G., and R. J. Fish. 1994. The defense industry of Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 129-132). University of Utah Press, Salt Lake City, UT.

Allen, C. D. 2002. Lots of lightning and plenty of people: an ecological history of fire in the upland southwest. In: T. R. Vale (Ed.). Fire, Native Peoples, and the Natural Landscape (pp. 143-193). Island Press, Washington, DC.

Allen, M. F., E. B. Allen, and N. E. West. 1987. Influence of parasitic and mutualistic fungi on temperate semi-desert shrubs. Bulletin of the Torrey Botanical Club 114: 272–279.

Amman, G. D. 1975. Insects affecting lodgepole pine productivity. In: D. M. Baumgartner (Ed.). Proceedings of Management of Lodgepole Pine Ecosystems Symposium (pp. 310-341). Washington State University Cooperative Extension Service, Bellingham, WA.

Anderson, A., and K. C. McCuistion. 2008. Evaluating strategies for ranching in the 21st century: successfully managing rangeland for wildlife and livestock. Rangelands 30(2): 8-14.

Anderson, V. J. 1989. Land status in Utah. In: K. J. Johnson (Ed.). Rangeland Resources of Utah (pp. 57-73). Utah State University Cooperative Extension Service, Logan, UT.

Arrington, L. J. 1994. Colonization of Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 106-108). University of Utah Press, Salt Lake City, UT.

Atwood, G. 1994. Geology of Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 219-222). University of Utah Press, Salt Lake City, UT.

Atwood, W. W. 1909. Glaciation of the Uinta and Wasatch Mountains. United States Geological Survey, Professional Paper 61. Government Printing Office, Washington DC.

Bailey, R. G. 1995. Descriptions of the Ecoregions of the United States (2nd Edition). USDA Forest Service Miscellaneous Publication 1391.

Baker, W. L., and D. Ehle. 2001. Uncertainty in surface-fire history: the case of ponderosa pine forests in the western United States. Canadian Journal of Forest Research 31: 1205-1226.

Bartos, D. L., and R. B. Campbell, Jr. 1998. Decline of quaking aspen in the Interior West – examples from Utah. Rangelands 20(1): 17-24.

Bartos, D. L. 2008. Great Basin aspen ecosystems. In: J. C. Chambers, N. Devoe, and A. Evenden (Eds.). Collaborative management and research in the Great Basin – examining the issues and developing framework for action. USDA Forest Service General Technical Report RMRS-GTR-204 (pp. 57-60). Fort Collins, CO.

Bauman, J. M. 1994. Colorado Plateau. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 108-109). University of Utah Press, Salt Lake City, UT.

Bearnson, M. S. 1994. John Wesley Powell. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 439-440). University of Utah Press, Salt Lake City, UT.

Beck, J. L., and D. L. Mitchell. 2000. Influences of livestock grazing on sage grouse habitat. Wildlife Society Bulletin 28(4): 993-1002.

Belsky, A. J., and D. M. Blumenthal. 1997. Effects of livestock grazing on stand dynamics and soils in upland forest of the interior west. Conservation Biology 11(2): 315-327.

Berry, D. 1978. Effects of urbanization on agricultural activities. Growth and Change 9(3): 2-8.

Blaisdell, J. P., and R. C. Holmgren. 1984. Managing Intermountain rangelands – salt-desert shrub ranges. USDA Forest Service General Technical Report INT-163. Intermountain Forest and Range Experiment Station, Ogden, UT.

Blake, D. 1994. Golden Spike National Historic Site. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 226-227). University of Utah Press, Salt Lake City, UT.

Bleich, V. C., J. G. Kie, E. R. Loft, T. R. Stephenson, M. W. Oehler, and A. L. Medina. 2005. Managing rangelands for wildlife. In: C. E. Braun (Ed.). Techniques for Wildlife Investigations and Management (pp. 873-897). The Wildlife Society, Bethesda, MD.

Bock, C. E., V. A. Saab, T. D. Rich, and D. S. Dobkin. 1993. Effects of livestock grazing on neotropical migratory landbirds in western North America. In: D. M. Finch, and P. W. Stangel (Eds.). Status and management of neotropical migratory birds (pp. 296-309). USDA Forest Service General Technical Report RM-229. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Bon, R. L., and K. A. Krahulec. 2008. 2007 Summary of Mineral Activity in Utah. Utah Department of Natural Resources. Utah Geological Survey. Salt Lake City, UT. <http://geology.utah.gov/utahgeo/rockmineral/activity/min2007.pdf>.

Borman, M. M. 2005. Forest stand dynamics and livestock grazing in historical context. Conservation Biology 19(5): 1658-1662.

Bowns, J. E. 1985. Rehabilitation and management of Gambel oak (*Quercus gambelii*) dominated ranges in southwestern Utah. In: K. L Johnson (Ed.). Proceeding of the Third Utah Shrub Ecology Workshop (pp 29-32). Utah State University, Logan, UT.

Brock, J. H. 1988. Livestock biological control in brush/weed management programs. Rangelands 10(1): 32-34.

Brooks, M. L., and D. A. Pyke. 2001. Invasive plants and fire in the deserts of North America. In: K. E. M. Galley and T. P. Wilson (Eds.). Proceedings of the Invasive Species Workshop: the Role of Fire in the Control and Spread of Invasive Species (pp. 1-14). Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, FL.

Brueckner, J. K. 2000. Urban sprawl: diagnosis and remedies. International Regional Science Review 23: 160-171.

Burchell, R. W., A. Downs, B. McCann, and S. Mukherji. 2005. Sprawl Costs: Economic Impacts of Unchecked Development. Island Press, Washington DC.

Bureau of Economic and Business Research (BEBR). 2007. The Structure and Economic Impact of Utah's Oil and Gas Exploration and Production Industry: Phase I – The Uinta Basin. University of Utah, Salt Lake City, UT. <http://governor.utah.gov/publiclands/PLPCOStudies/EconomicImpactofO&GIndustryALL.pdf>.

Bureau of Land Management (BLM). 2007a. BLM and Its Predecessors. <http://www.blm.gov/wo/st/en/info/About_BLM/History.html>.

Bureau of Land Management (BLM). 2007b. Little Sahara Recreation Area. <http://www.blm.gov/ut/st/en/fo/fillmore/recreation/special_recreation/little_sahara_recreation.html>.

Bureau of Land Management (BLM). 2008. Healthy Lands Initiative. <http://www.blm.gov/wo/st/en/info/newsroom/2008/April/HLI_09_Fact_Sheets.html>.

Bureau of Land Management (BLM). 2009. President signs legislation that enhances protection for public lands in Utah. <http://www.blm.gov/ut/st/en/info/newsroom/ 2009/march/president_signs_legislation0.html>.

Campbell, E. E. 1989a. From colonization to statehood: introduction. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 93-95). Utah State University Press, Logan, UT.

Campbell, E. E. 1989b. The Mormon migrations to Utah. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 113-131). Utah State University Press, Logan, UT.

Campbell, E. E. 1989c. Early colonization patterns. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 133-152). Utah State University Press, Logan, UT.

Campbell, E. E. 1989d. Governmental beginnings. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 153-173). Utah State University Press, Logan, UT.

Carrara, P. E., and T. R Carroll. 1979. The determination of erosion rates from exposed tree roots in the Piceance Basin, Colorado. Earth Surface Process 4: 307-317.

Clary, W. P., S. Goodrich, and B. M. Smith. 1985. Response to Tebuthiuron by Utah juniper and mountain big sagebrush communities. Journal of Range Management 38: 56-60.

Clary, W. P., and R. C. Holmgren. 1982. Desert Experimental Range: establishment and research contribution. Rangelands 4(6): 261-264.

Clary, W. P., and A. R. Tiedemann. 1985. Biomass distribution in north central Utah Gambel oak stands. In: K L. Johnson (Ed.). Proceedings of the Third Utah Shrub Ecology Workshop (pp. 9-12). Utah State University, Logan, UT.

Columbia Encyclopedia, Sixth Edition. 2008. United States War Department. <http://www.encyclopedia.com/topic/United_States_War_Department.aspx>.

Davison, J. 1996. Livestock grazing in wildland fuel management programs. Rangelands 18(6): 242-245.

Defa, D. R. 1994. Goshute Indians. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 228-229). University of Utah Press, Salt Lake City, UT.

DeLoach, C. J., R. I. Carruthers, J. E. Lovich, T. L. Dudley, and S. D. Smith. 2000. Ecological interactions in the biological control of saltcedar (*Tamarix* spp.) in the United States: toward a new understanding. In: N. R. Spencer (Ed.). Proceedings of the X International Symposium on Biological Control of Weeds (pp. 819-873). Montana State University, Bozeman, MT.

Despain, M., and F. R. Gowans. 1994. James Bridger. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 51-52). University of Utah Press, Salt Lake City, UT.

DiTomaso, J. M. 2000. Invasive weeds in rangelands: species, impacts, and management. Weed Science 48: 255-265.

Dombeck, M. P., Williams, J. E., and C. A. Wood. 2004. Wildfire policy and public lands: integrating scientific understanding with social concerns across landscapes. Conservation Biology 18(4): 883-889.

Downs, J. F. 1966. The significance of environmental manipulation in the Great Basin cultural development. In: W. L. d'Azevedo, W. Davis, D. Fowler, and W. Suttles (Eds.). The Current Status of Anthropological Research in the Great Basin (pp. 39-55). Social Sciences and Humanities Publication No. 1. Desert Research Institute, Reno, NV.

Fisher, A. L. 1994. Physical geography of Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 216-219). University of Utah Press, Salt Lake City, UT.

Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8(3): 629-644.

Frost, R. A., and K. L. Launchbaugh. 2003. Prescription grazing for rangeland weed management: a new look at an old tool. Rangelands 25(6): 43-47.

Fuller, C. 1994. Uinta Basin. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 569-571). University of Utah Press, Salt Lake City, UT.

Godfrey, A. E., B. L. Everitt, and J. F. M. Duque. 2008. Episodic sediment delivery and landscape connectivity in the Mancos Shale badlands and Fremont River system, Utah, USA. Geomorphology 102(2): 242-251.

Gosnell, H., and W. R. Travis. 2005. Ranchland ownership dynamics in the Rocky Mountain West. Rangeland Ecology and Management 58(2): 191-198.

Graham, T. 1994. The Bureau of Land Management in Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (p. 63). University of Utah Press, Salt Lake City, UT.

Griffin, D. 2002. Prehistoric human impacts on fire regimes and vegetation in the northern Intermountain West. In: T. R. Vale (Ed.). Fire, Native Peoples, and the Natural Landscape (pp. 77-100). Island Press, Washington DC.

Gwynn, J. W. 2007. Taking another look at Utah's tar sand resources. Utah Geological Survey. Survey Notes 39: 8-9. <http://geology.utah.gov/surveynotes/articles/pdf/tarsand_resources_39-1.pdf>.

Hallaran, K. B. 1994. Bonneville Salt Flats. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 47-48). University of Utah Press, Salt Lake City, UT.

Harper, K. T., F. J. Wagstaff, and L. M. Kunzler. 1985. Biology and management of the Gambel oak type: a literature review. USDA Forest Service General Technical Report INT-179. Intermountain Forest and Range Experiment Station, Ogden, UT.

Hayward, C. L. 1948. Biotic communities of the Wasatch chaparral, Utah. Ecological Monographs 18: 473-506.

Hayward, C. L. 1952. Alpine biotic communities of the Uinta Mountains, Utah. Ecological Monographs 22: 93-120.

Hebertson, D., and N. McMichael. 2009. News Release: SITLA Issues First Wind Power Lease. School and Institutional Trust Land Administration. Salt Lake City, UT. <http://www.utahtrustlands.com/news/docs/2009_02_10-News_Release-FirstWind.pdf>.

Hill, M. S. 1989. The rise of the Mormon Kingdom of God. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 97-112). Utah State University Press, Logan, UT.

Holechek, J. L. 2001. Western ranching at the crossroads. Rangelands 23(1): 17-21.

Holechek, J. L., and J. Hawkes. 2007. Western ranching, trade policies, and peak oil. Rangelands 29(5): 28-32.

Holt, R. L. 1994. Paiute Indians of Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 408-410). University of Utah Press, Salt Lake City, UT.

Hull, A. C., and M. K. Hull. 1974. Presettlement vegetation of Cache Valley, Utah and Idaho. Journal of Range Management 27(1): 27-29.

Hurst, W. 1994. Anasazi. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 10-12). University of Utah Press, Salt Lake City, UT.

Jacobs, J. L. 1984. Utah: where the Society for Range Management was organized. Rangelands 6(5): 214-216.

Jeffries, D. L., and J. M. Klopatek. 1987. Effects of grazing on the vegetation of the blackbrush association. Journal of Range Management 40: 390-392.

Johnson, K. J., and V. J. Anderson. 1989. Utah as a geographical entity. In: K. J. Johnson (Ed.). Rangeland Resources of Utah (pp. 2-3). Utah State University Cooperative Extension Service, Logan, UT.

Johnson, M., and M. Higgs. 2007. Tamarisk – an overview of Grand County's biological control program. <http://www.grandcountyutah.net/pdf/weeds/Tamarisk%20Control%20Grand%20County.pdf>.

Johnson, V. J. 1984. Prescribed burning: requiem or renaissance? Journal of Forestry 82(2): 82-91.

Kay, C. E. 2007. Are lightning fires unnatural?: a comparison of aboriginal and lightning ignition rates in the United States. In: R. E. Masters, and K. E. M. Galley (Eds.). Proceedings of the 23rd Tall Timbers Fire Ecology Conference: Fire in Grassland and Shrubland Ecosystems (pp. 16-28). Tall Timbers Research Station, Tallahassee, FL.

Knapp, P. A. 1996. Cheatgrass (*Bromus tectorum L.*) dominance in the Great Basin Desert: history, persistence, and influences to human activities. Global Environmental Change 6(1): 37-52.

Knipe, O. D. 1983. Effects of angora goat browsing on burned-over Arizona chaparral. Rangelands 5(6): 252-255.

Kotval, Z., and J. Mullin. 2006. Economic framework: the economics of sprawl. In: D. C. Soule (Ed.). Urban Sprawl: A Comprehensive Reference Guide (pp.79-89). Greenwood Publishing Group, Inc., Westport, CT.

Larson, G. O. 1989. Government, politics, and conflict. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 243-256). Utah State University Press, Logan, UT.

Larson, G. O., and R. D. Poll. 1989. The forty-fifth state. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 387-404). Utah State University Press, Logan, UT.

Leatherman, D. A., I. Aguayo, and T. M. Mehall. 2007. Mountain Pine Beetle. Colorado State University Extension Fact Sheet, Insect Series No. 5.528. <http://www.ext.colostate.edu/pubs/insect/05528.html>.

Lewis, D. R. 1994a. Native Americans in Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 389-391). University of Utah Press, Salt Lake City, UT.

Lewis, D. R. 1994b. Ute Indians. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 608-609). University of Utah Press, Salt Lake City, UT.

Lewis, M. E. 1970. Alpine rangelands of the Uinta Mountains, Ashley and Wasatch National Forests. USDA Forest Service. Ogden, UT.

Lewis, P. A., C. J. DeLoach, A. E. Knutson, J. L. Tracy, and T. O. Robbins. 2003. Biology of *Diorhabda elongate deserticola* (*Coleoptera: Chrysomelidae*), an Asian leaf beetle for biological control of saltcedars (*Tamarix* spp.) in the United States. Biological Control 27: 101-116.

Liffman, R. H., L. Huntsinger, and L. C. Forero. 2000. To ranch or not to ranch: home on the urban range? Journal of Range Management 53(4): 632-370.

Lopez, R. A., A. O. Adelaja, and M. S. Andrews. 1988. The effects of suburbanization on agriculture. American Journal of Agricultural Economics 70(2): 346-358.

Lowry, J. L. Jr., R. D. Ramsey, K. Boykin, D. Bradford, P. Comer, S. Falzarano, W. Kepner, J. Kirby, L. Langs, J. Prior-Magee, G. Manis, L. O'Brien, K. Pohs, W. Rieth, T. Sajwaj, S. Schrader, K. A. Thomas, D. Schrupp, K. Schulz, B. Thompson, C. Wallace, C. Velasquez, E. Waller, and B. Wolk. 2007. Mapping meso-scale land cover over very large geographic areas within a collaborative framework: a case study of the Southwest Regional Gap Analysis Project (SWReGAP). Remote Sensing of Environment 108: 59-73.

Lugo, A. E., F. J. Swanson, O. R. Gonzalez, M. B. Adams, B. Palik, R. E. Thill, D. G. Brockway, C. Kern, R. Woodsmith, and R. Musselman. 2006. Long-term research at USDA Forest Service's experimental forests and ranges. BioScience 56(1): 39-48.

Lyman, E. L. 1994. Statehood for Utah. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 529-531). University of Utah Press, Salt Lake City, UT.

Mackintosh, B. 1999. The National Park Service: A Brief History. <http://www.nps.gov/history/history/hisnps/NPSHistory/briefhistory.htm>.

MacMahon, J. A., and F. H. Wagner. 1985. The Mojave, Sonoran and Chihuahuan deserts of North America. In: M. Evenari, I. Noy-Meir, and D. W. Goodall (Eds.). Ecosystems of the World: Hot Deserts and Arid Shrublands (pp.105-202). Elsevier Science Publication Company, Amsterdam, Netherlands.

Madany, M. H., and N. E. West. 1983. Livestock grazing-fire regime interaction within montane forests of Zion National Park, Utah. Ecology 64(4): 661-667.

Madany, M. H., and N. E. West. 1984. Vegetation of two relict mesas in Zion National Park. Journal of Range Management 37: 456-461.

Madsen, D. B. 1994a. The Fremont. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 203-205). University of Utah Press, Salt Lake City, UT.

Madsen, B. D., 1994b. Shoshoni Indians (Northwestern Bands). In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 497-498). University of Utah Press, Salt Lake City, UT.

Masters, R. A., and R. L. Sheley. 2001. Principles and practices for managing rangeland invasive plants. Journal of Range Management 54(5): 502-517.

McAvoy, D., M. Kuhns, and J. Black. 2004. Utah Forest Types: An Introduction to Utah Forests. Utah State University Extension Publication NR/FF/011. <http://extension.usu.edu/forestry/Reading/Assets/PDFDocs/NR_FF/NRFF011.pdf>.

McPherson, R. S. 1994. Navajo Indians. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 391-393). University of Utah Press, Salt Lake City, UT.

McPherson, R. S., and M. J. Yazzie. 2009. The White Mesa Utes. In: The History of Utah's American Indians. <http://historytogo.utah.gov/people/ethnic_cultures/the_history_of_utahs_american_indians/chapter6.html>.

Miller, D. E. 1989a. The fur trade and the mountain men. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 53-69). Utah State University Press, Logan, UT.

Miller, D. E. 1989b. Explorers and trail blazers. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 71-91). Utah State University Press, Logan, UT.

Miller, R. F., and E. K. Heyerdahl. 2008. Fine-scale variation of historical fire regimes in sagebrush-steppe and juniper woodland: an example from California, USA. International Journal of Wildland Fire 17: 245-254.

Miller, R. F., J. A. Rose., T. Svejcar, J. Bates, and K. Paintner. 1995. Western juniper woodlands: 100 years of plant succession. In: D. W. Shaw, E. F. Aldon, and C. LoSapio (Eds.). Desired Future Conditions for Pinon-Juniper Ecosystems (pp. 5-8). United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-258. Fort Collins, CO.

Miller, R. F., and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52(6): 550-559.

Miller, R. F., and R. J. Tausch. 2001. The role of fire in juniper and pinyon woodlands: a descriptive analysis. In: K. E. M. Galley and T. P. Wilson (Eds.). Proceedings of the Invasive Species Workshop: the Role of Fire in the Control and Spread of Invasive Species (pp.15-30). Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, FL.

Milligan, M. R. 2000. How was Utah's topography formed? Utah Geological Survey, Survey Notes 32(1). <http://ugs.utah.gov/surveynotes/gladasked/gladtopoform.htm>.

Mongha, N., C. L. Hartman, and E.D. Stafford. 2006. An Analysis of the Economic Impact on Utah County, Utah, from the Development of Wind Power Plants. Renewable Energy for Rural Economic Development, College of Business. Utah State University, Logan, UT.

Muhn, J., and H. R. Stuart. 1988. Opportunity and Challenge, The Story of BLM. United States Department of Interior. Bureau of Land Management. United States Government Printing Office, Washington, DC.

Murphy, D. R. 1989. Physical features of Utah. In: Johnson, K. J. (Ed.). Rangeland Resources of Utah (pp. 4-5) Utah State University Cooperative Extension Service, Logan, UT.

Nader, G., Z. Henkin, E. Smith, R. Ingram, and N. Narvaez. 2007. Planned herbivory in the management of wildfire fuels. Rangelands 29(5): 18-24.

National Agricultural Statistics Service (NASS). 2009. Utah Data – Farm Numbers. <http://www.nass.usda.gov/Statistics_by_State/Utah>.

National Interagency Coordination Center (NICC). 2007. Wildlife Fire Summary and Statistics 2007. <http://www.predictiveservices.nifc.gov/intelligence/2007_statssumm/intro_summary.pdf>.

National Park Service (NPS). 1999. Arches National Park: Human History. <http://www.nps.gov/arch/planyourvisit/upload/human.pdf>.

National Park Service (NPS). 2005. The National Parks: Shaping the System. Harpers Ferry Center, National Park Service. United States Department of the Interior. Washington, DC. <http://www.nps.gov/history/history/online_books/shaping/index.htm>.

National Park Service (NPS). 2006a. Canyonlands National Park: Park Founders. <http://www.nps.gov/cany/historyculture/parkfounders.htm>.

National Park Service (NPS). 2006b. Zion National Park: History and Culture. <http://www.nps.gov/zion/historyculture/index.htm>.

National Park Service (NPS). 2007. Capitol Reef National Park: History and Culture. <http://www.nps.gov/care/historyculture/index.htm>.

National Park Service (NPS). 2009a. Golden Spike National Historic Site. <http://www.nps.gov/gosp>.

National Park Service (NPS). 2009b. The National Park Service in Utah. <http://www.nps.gov/state/ut>.

National Park Service (NPS). No date. Fire frequency and intensity in ponderosa pine forests. <http://www.nps.gov/archive/romo/downloads/CDRLC/summaries/ponderosa_fire.pdf>.

Natural Resources Conservation Service (NRCS). 2003. Farm Bill 2002: Conservation of Private Grazing Land Program Fact Sheet. <http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/CPGLFct.pdf>.

Natural Resources Conservation Service (NRCS). 2004a. Farm Bill 2002: Wildlife Habitat Incentives Program Fact Sheet. <http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/WHIPFct.pdf>.

Natural Resources Conservation Service (NRCS). 2004b. Farm Bill 2002: Farm and Ranch Lands Protection Program Fact Sheet. <http://www.nrcs.usda.gov/programs/farmbill/2002/pdf/FRPPFct.pdf>.

Natural Resources Conservation Service (NRCS). 2005. Landowner Incentive Program (LIP). <http://www.ut.nrcs.usda.gov/programs/lip.html>.

Natural Resources Conservation Service (NRCS). 2007. Farm Bill 2002: Agricultural Management Assistance Fact Sheet. <http://www.nrcs.usda.gov/programs/AMA/2007_AMA_Fact.pdf>.

Natural Resources Conservation Service (NRCS). 2009a. Overview and History of Hydrologic Units and the Watershed Boundary Dataset (WBD). <http://www.ncgc.nrcs.usda.gov/products/datasets/watershed/history.html>.

Natural Resources Conservation Service (NRCS). 2009b. U.S. General Soil Map (STATSGO2) Description. <http://soils.usda.gov/survey/geography/statsgo/description.html>.

Nelson, S. R. 1997. History of the Uinta National Forest: A Century of Stewardship. Uinta National Forest. <http://www.fs.fed.us/r4/uwc/about/uinta/unf_history/pdf/unf_history _all.pdf>.

Newell, D., S. Taylor and H. F. Anzalone. 2008. Utah's Energy Use and Resources Powering Our Standard of Living. Utah Foundation Executive Summary. Report Number 685. Salt Lake City, UT. <http://www.utahfoundation.org/img/pdfs/rr685summary.pdf>.

Nichols, J. D. 1995. Fellow trappers called Etienne Provost "The Man of the Mountains." History Blazer, August 1995. <http://historytogo.utah.gov/people/etienneprovost.html>.

Nielson, J. S., Innis, L. K. Pollock, H. Roads-Weaver, and A. Shutak. 2006. Renewable Energy Atlas of the West, a Guide to the Region's Resource Potential. The Energy Foundation. San Francisco, CA. <http://www.energyatlas.org/PDFs/atlas_state_UT.pdf>.

Omernik, J. M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77(1): 118-125.

Parker, K. C. 2002. Fire in the pre-European lowlands of the American Southwest. In: T. R. Vale (Ed.). Fire, Native Peoples, and the Natural Landscape (pp. 101-141). Island Press, Washington DC.

Peterson, C. S. 1977. Utah: A Bicentennial History. W. W. Norton and Company, Inc., New York, NY.

Peterson, G. B. 1994. The Great Basin. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 232-233). University of Utah Press, Salt Lake City, UT.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52: 273-288.

Poll, R. D. 1994. Deseret. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 138-139). University of Utah Press, Salt Lake City, UT.

Pollet, J., and P. N. Omi. 2002. Effect of thinning and prescribed burning on crown fire severity in ponderosa pine forests. International Journal of Wildland Fire 11: 1-10.

Powell, A. K. 1996. Utah's First State Park. History Blazer, November 1996. <http://historytogo.utah.gov/utah_chapters/utah_today/utahsfirststatepark.html>.

Prevedel, D. A., and C. M. Johnson. 2005. Beginnings of range management: Albert F. Potter, first Chief of Grazing, U.S. Forest Service, and a photographic comparison of his 1902 Forest Reserve Survey in Utah with conditions 100 years later. USDA Forest Service General Technical Report R4-VM 2005-01. Intermountain Region, Ogden, UT.

Prevedel, D. A., E. D. McArthur, and C. M. Johnson. 2005. Beginnings of range management: an anthology of the Sampson-Ellison photo plots (1913 to 2003) and a short history of the Great Basin Experiment Station. USDA Forest Service General Technical Report RMRS-GTR-154. Rocky Mountain Research Station. Fort Collins, CO.

Rawley, E. V., and L. Rawley. 1967. A Brief History of the Utah Fish and Game. Utah Division of Wildlife Resources. <http://wildlife.utah.gov/about/history.php>.

Reese, G. A. 1981. Diversity and production of herbaceous vegetation in a northern Utah subalpine chronosequence. MS Thesis. Utah State University, Logan, UT.

Resnik, J., G. Wallace, M. Brunson, and J. Mitchell. 2006. Open spaces, working places. Rangelands 28(5): 4-9.

Rice, P. M., G. R. McPherson, and L. J. Rew. 2008. Fire and nonnative invasive plants in the interior west bioregion. In: K. Zouhar, J. K. Smith, S. Sutherland, and M. L. Brooks (Eds). Wildland fire in ecosystems: fire and nonnative invasive plants (pp.141-174). USDA Forest Service General Technical Report RMRS-GTR-42-vol.6. Rocky Mountain Research Station. Fort Collins, CO.

Roger, G. F. 1982. Then and now: a photographic history of vegetation change in the central Great Basin Desert. University of Utah Press, Salt Lake City, UT.

Rogers, K. 2000. Lifeways on the Land: The Shoshone of Northern Utah. In: Beehive History 26. Salt Lake City, UT.

Rotham, H. 1999. The Antiquities Act and national monuments: a progressive conservation legacy. Cultural Resource Management 4: 16-18.

Sadler, R. W. 1994. Miles Goodyear. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 227-228). University of Utah Press, Salt Lake City, UT.

Sampson, A. W. 1952. Range Management Principles and Practices. John Wiley and Sons, Inc., New York, NY.

Samuels, M. L., and J. L Betancourt. 1982. Modeling the longterm effects of fuelwood harvests on pinyon-juniper woodlands. Environmental Management 6: 505-515.

Schoennagel, T., T. T. Veblen, and W. H. Romme. 2004. The interaction of fire, fuels, and climate across Rocky Mountain forests. BioScience 54(7): 661-676.

Schuster, E. G., P. R. Beckley, K. M. Gebert, and M. J. Niccolucci. 1999. An analysis of PILT-related payments and likely property tax liability of federal resource management lands. USDA Forest Service General Technical Report RMRS-GTR-36WWW. Rocky Mountain Research Station, Ogden, UT. <http://www.fs.fed.us/rm/pubs/rmrs_gtr036.pdf>.

Scrattish, N. 1985. Historic Resource Study: Bryce Canyon National Park. United States Department of the Interior, National Park Service, Rock Mountain Regional Office. <http://www.nps.gov/history/history/online_books/brca/hrs.htm>.

Sheley, R. L., J. S. Jacobs, and J. M. Martin. 2004. Integrating 2,4-D and sheep grazing to rehabilitate spotted knapweed infestations. Journal of Range Management 57(4): 371-375.

Sheridan, T. E. 2007. Embattled ranchers, endangered species, and urban sprawl: the political ecology of the new American West. Annual Review of Anthropology 36: 121-138.

Sherriff, R. L., and T. T. Veblen. 2007. A spatially-explicit reconstruction of historical fire occurrence in the ponderosa pine zone of the Colorado Front Range. Ecosystems 10: 311-323.

Slack, K. 2008. U.S. Geothermal Power Production and Development Update. Geothermal Energy Association. Washington, DC. <http://www.geo-energy.org/publications/reports/Industry_Update_March_Final.pdf>.

Society for Range Management (SRM). No date. Biodiversity of rangelands. <http://www.rangelands.org/pdf/Biodiversity_Issue_Paper_FA.pdf>.

Soule, D. C. 2006. Historical framework: cities and their regions, suburbanization, and federal policies. In: D. C. Soule (Ed.). Urban Sprawl: A Comprehensive Reference Guide (pp. 12-25). Greenwood Publishing Group, Inc., Westport, CT.

Spence, M. L. 1994. John Charles Fremont. In: A. K. Powell (Ed.). Utah History Encyclopedia (pp. 205-206). University of Utah Press, Salt Lake City, UT.

Spencer, A. C. 1984. Nut crops from Utah rangelands: the pinyon tress. In: K L. Johnson (Ed.). Proceedings of the Second Utah Shrub Ecology Workshop (pp.15-17). Utah State University, Logan, UT.

Stam, B. R., J. C. Malechek, D. L. Bartos, J. E. Bowns, and E. B. Godfrey. 2008. Effect of conifer encroachment into aspen stands on understory biomass. Rangeland Ecology and Management 61: 93-97.

State of Utah School and Institutional Trust Lands Administration (SITLA). 2008a. Fiscal Year 2008 Annual Report. <http://www.utahtrustlands.com/news/docs/ AnnualRp08.pdf>.

State of Utah School and Institutional Trust Lands Administration (SITLA). 2008b. About Utah Trustlands. <http://www.utahtrustlands.com/about/index.html>.

Steen, H. K. 1991. The U.S. Forest Service: A History. University of Washington Press, Seattle, WA.

Stevens, R., and J. N. Davis. 1985. Opportunities for improving forage production in the Gambel oak types of Utah. In: K. L. Johnson (Ed.). Proceedings of the Third Utah Shrub Ecology Workshop (pp. 37-41). Utah State University, Logan, UT.

Stevens, J. S., J. Taylor, M. Hufstetler, and M. Rossillon. 2006. Discovery and re-discovery in the White River Badlands: a historic resource study. Badlands National Park, South Dakota. <http://www.nps.gov/history/history/online_books/badl/hrs/ contents.htm>

Stewart, G. 1936. History of range use. In: The Western Range. Letter from the Secretary of Agriculture transmitting in response to Senate Resolution No. 289: a report on the Western Range – a great but neglected natural resource. United States Government Printing Office, Washington, DC.

Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. Range Management. McGraw-Hill Book Company, Inc., New York, NY.

Sustainable Rangelands Roundtable (SRR). 2005. Sustainable Rangelands Roundtable 2005 Progress Report. <http://sustainablerangelands.warnercnr.colostate.edu/Images/ ProgressReport.pdf>.

Sutter, J. V., M. E. Anderson, K. D. Bunnell, M. F. Canning, A. G. Clark, D. E. Dolsen, and F. P. Howe. 2005. Utah Comprehensive Wildlife Conservation Strategy (CWCS). Utah Division of Wildlife Resources Publication 05-19. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City, UT.

Tabet, D. 2006. Utah likely to be a key player in future oil shale development. Utah Geologic Survey, Survey Notes 38: 5-6. <http://geology.utah.gov/surveynotes/snt38-1.pdf>.

Tausch, R. J., N. E. West, and A. A. Nabi. 1981. Tree age and dominance patterns in Great Basin pinyon-juniper woodlands. Journal of Range Management 34: 259-264.

Tew, R. K. 1967. Soil moisture depletion by Gambel oak in central Utah. USDA Forest Service Research Note INT-74. Intermountain Forest and Range Experiment Station, Ogden, UT.

Tew, R. K. 1969. Converting Gambel oak sites to grass reduces soil-moisture depletion. USDA Forest Service Research Note INT-104. Intermountain Forest and Range Experiment Station, Ogden, UT.

Thilenius, J. 1975. Alpine range management in the western United States – principles, practices, and problems: the status of our knowledge. USDA Forest Service Research Paper RM-157. Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Thornton, P. E., S. W. Running, and M. A. White. 1997. Generating surfaces of daily meteorological variables over large regions of complex terrain. Journal of Hydrology 190: 214-251.

Touchan, R., T. W. Swetnam, and H. D. Grissino-Mayer. 1995. Effects of livestock grazing on pre-settlement fire regimes in New Mexico. In: J. K. Browns, R. W. Mutch, C. W. Spoon, and R. H. Wakimoto (Eds.). Proceedings: Symposium on Fire in Wilderness and Park Management (pp. 268-272). USDA Forest Service General Technical Report INT-GTR-320. Intermountain Research Station, Ogden, UT.

Tyler, S. L. 1989. The earliest people. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 23-34). Utah State University Press, Logan, UT.

United States Air Force (USAF). 2009a. A Short History of Hill Air Force Base. U.S. Air Force Fact Sheet 5830. <http://www.hill.af.mil/library/factsheets/factsheet. asp?fsID=5830>.

United States Air Force (USAF). 2009b. Utah Test and Training Range. U.S. Air Force Fact Sheet 5614. <http://www.hill.af.mil/library/factsheets/factsheet.asp?id=5614>.

United States Department of Agriculture Sustainable Agriculture Research and Education (USDA SARE) Program. 2008. Sustainable Agriculture Research and Education. <http://www.sare.org/about>.

United States Department of Defense (US DOD). 2009. DoD 101: An Introductory Overview of the Department of Defense. <http://www.defenselink.mil/pubs/dod101>.

United States Department of Energy (US DOE). 2008. State Energy Alternatives. U.S. Department of Energy Energy Efficiency and Renewable Energy. Washington, DC. <http://apps1.eere.energy.gov/states/state_specific_information.cfm/state=UT>.

United States Department of State (US DOS). 2009. National Security Act of 1947. <http://www.state.gov/r/pa/ho/time/cwr/17603.htm>.

United States Environmental Protection Agency (US EPA). 2009. Ecoregions of the United States. <http://www.epa.gov/wed/pages/ecoregions/na_eco.htm>.

United States Fish and Wildlife Service (USFWS). 2001. U.S. Fish and Wildlife Service Presence in Utah. <http://www.fws.gov/mountain-prairie/reference/briefing_book_ut_2000.pdf>.

United States Fish and Wildlife Service (USFWS). 2007. U.S. Fish and Wildlife Service: Fish Springs National Wildlife Refuge. <http://www.fws.gov/fishsprings/Description.html>.

United States Fish and Wildlife Service (USFWS). 2008a. U.S. Fish and Wildlife Service Agency Overview: Conserving the Nature of America. <http://www.fws.gov/pdfs/AgencyOverviewTransition2009.pdf>.

United States Fish and Wildlife Service (USFWS). 2008b. U.S. Fish and Wildlife Service: Ouray National Wildlife Refuge General Brochure. <http://www.fws.gov/ouray/ brochure.html>.

United States Fish and Wildlife Service (USFWS). 2009a. History of the National Wildlife Refuge System. <http://www.fws.gov/refuges/history>.

United States Fish and Wildlife Service (USFWS). 2009b. U.S. Fish and Wildlife Service Congressional and Legislative Affairs: Digest of Federal Resource Laws. <http://www.fws.gov/laws/Lawsdigest.html>.

United States Fish and Wildlife Service (USFWS). 2009c. U.S. Fish and Wildlife Service: Bear River Migratory Bird Refuge History. <http://www.fws.gov/refuges/profiles/index.cfm?id=65530>.

United States Forest Service (USFS). 2006. Forest Legacy Program in Utah: A State and Private Forestry Fact Sheet. <http://www.fs.fed.us/r1-4/spf/utah/06_0508_ut_legacy.pdf>.

United States Forest Service (USFS). 2008. Ashley National Forest: History. <http://gis.fs.fed.us/r4/ashley/about/history.shtml>.

United States Forest Service (USFS). 2009. U.S. Forest Service History: Franklin B. Hough. <http://www.foresthistory.org/ASPNET/People/Hough/Hough.aspx>.

United States Geological Survey (USGS). 2002. Born of fire – restoring sagebrush steppe. Publication USGS FS-126-02. <http://fresc.usgs.gov/products/fs/fs-126-02.pdf>.

United States Geological Survey (USGS). 2009. A Tapestry of Time and Terrain: The Union of Two Maps – Geology and Topography. <http://tapestry.usgs.gov/physiogr/physio.html>.

United States Government Accountability Office (US GAO). 2005. Report to Congressional Requesters. Livestock grazing: federal expenditures and receipts vary, depending on the agency and the purpose of the fee charged. Report GAO-05-869. Washington, DC.

Utah Department of Agriculture and Food (UDAF). 2007. Utah Department of Agriculture and Food 2007 Annual Report. <http://ag.utah.gov/conservation/GIPAnnualReport.pdf>.

Utah Department of Agriculture and Food (UDAF). 2008. War on Cheatgrass Legislation Passes. <http://ag.utah.gov/news/CheatgrassLegis.html>.

Utah Department of Agriculture and Food (UDAF). 2009. About the Utah Conservation Commission. <http://ag.utah.gov/conservation/AboutUCC.html>.

Utah Department of Natural Resources (UDNR). 2009a. About Utah Forestry, Fire, and State Lands. <http://naturalresources.utah.gov/divisions/forestry-fire-state-lands.html>.

Utah Department of Natural Resources (UDNR). 2009b. About the Utah Division of Wildlife Resources. <http://naturalresources.utah.gov/divisions/wildlife.html>.

Utah Department of Natural Resources (UDNR). 2009c. About Utah State Parks and Recreation. <http://naturalresources.utah.gov/divisions/state-parks.html>.

Utah Division of Archives and Records Service (UDARS). 2009a. Utah School and Institutional Trust Lands Administration. <http://archives.state.ut.us>.

Utah Division of Archives and Records Service (UDARS). 2009b. Utah State Land Board. <http://archives.state.ut.us>.

Utah Division of Archives and Records Service (UDARS). 2009c. Utah Division of Wildlife Resources. <http://archives.state.ut.us>.

Utah Division of Archives and Records Service (UDARS). 2009d. Utah Division of Parks and Recreation. <http://archives.state.ut.us>.

Utah Division of Forestry, Fire, and State Lands (UDFFSL). 2007. Northern Utah Regional Wildfire Protection Plan. <http://www.utahfireinfo.gov/CWPP/northernutah/FINAL_Northern_UT%20RWPP.pdf>.

Utah Division of Forestry, Fire, and State Lands (UDFFSL). 2008. Utah Forest Legacy Program. <http://www.ffsl.utah.gov/forestryassist/Legacy/Legacy.php>.

Utah Division of Forestry, Fire, and State Lands (UDFFSL). 2009. Mission Statement. <http://www.ffsl.utah.gov/ffsl.htm>.

Utah Division of Indian Affairs (UDIA). 2009a. White Mesa Ute Board. <http://indian.utah.gov/utah_tribes_today/whitemesa.html>.

Utah Division of Indian Affairs (UDIA). 2009b. Utah Tribes Today. <http://indian.utah.gov/utah_tribes_today/index.html>.

Utah Division of Water Resources (UDWaR). 2004a. Weber River Basin: Planning for the Future. Utah State Water Plan. <http://www.water.utah.gov/planning/SWP/Weber_riv/WeberDraft0704.pdf>.

Utah Division of Water Resources (UDWaR). 2004b. Bear River Basin: Planning for the Future. Utah State Water Plan. <http://www.water.utah.gov/planning/SWP/bear/bearRiver-1A.pdf>.

Utah Division of Wildlife Resources (UDWR). 2007. Bison Unit Management Plan: Unit #15 Henry Mountains. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City, UT. <http://wildlife.utah.gov/hunting/biggame/pdf/bison_15.pdf>.

Utah Division of Wildlife Resources (UDWR). 2009. About the Division of Wildlife Resources. <http://wildlife.utah.gov/about>.

Utah Energy Office (UEO). 2009. Oil Shale/Tar Sands. Governor's Energy Policy. Salt Lake City, UT. <http://www.energy.utah.gov/energy/governors_priorities/oil_shale_tar_sands.html>.

Utah Geological Survey (UGS). 2009a. Utah's Fossil Fuels. Utah Department of Natural Resources. Salt Lake City, UT. <http://geology.utah.gov/utahgeo/energy/fossil_fuels.htm>.

Utah Geological Survey (UGS). 2009b. Geothermal Resources in Utah. Utah Department of Natural Resources. Salt Lake City, UT. <http://geology.utah.gov/emp/geothermal/geothermal_resources_in_utah.htm>.

Utah Geological Survey (UGS). 2009d. Hydroelectric Power. Utah Department of Natural Resources. Salt Lake City, UT. <http://ugs.utah.gov/sep/renewable_energy/hydro.htm>.

Utah Geological Survey (UGS). 2009e. Biomass. Utah Department of Natural Resources. Salt Lake City, UT. <http://ugs.utah.gov/sep/renewable_energy/biomass.htm>.

Utah Governor's Office of Planning and Budget (UGOPB). 2008. LeRay McAllister Critical Land Conservation Fund: Frequently Asked Questions. <http://planning.utah.gov/lerayfaqs.html>.

Utah Governor's Office of Planning and Budget (UGOPB). 2009. 2009 Economic Report to the Governor. Salt Lake City, UT. <http://governor.utah.gov/dea/ERG/2009ERG.pdf>.

Utah Lake Commission (ULC). 2009. Utah Lake Master Plan. <http://www.utahlakecommission.org/Final_Draft_Master_Plan.pdf>.

Utah Mining Association (UMA). 2009. Coal. Utah Mining Association, Salt Lake City, UT. <http://www.utahmining.org/coaltypes2.htm>.

Utah Partners for Conservation and Development (UPCD). 2009. Utah Partners for Conservation and Development. <http://www.utahpcd.info/index.html>.

Utah Quality Growth Commission (UQGC). 2008. Utah's Quality Growth Commission. <http://governor.utah.gov/Quality>.

Utah State University (USU) Extension. 2009. Range Plants of Utah: Lodgepole Pine. <http://extension.usu.edu/rangeplants/htm/lodgepole-pine>.

Utah Watershed Restoration Initiative (UWRI). 2009. About Utah's Watershed Restoration Initiative. <http://wildlife.utah.gov/watersheds/about/index.php>.

Van Hooser, D. D., and A. W. Green. 1983. Utah's forest resources, 1978. USDA Forest Service Resource Bulletin INT-30. Intermountain Forest and Range Experiment Station, Ogden, UT.

Vavra, M., C. G. Parks, and M. J. Wisdom. 2007. Biodiversity, exotic plant species, and herbivory: the good, the bad, and the ungulate. Forest Ecology and Management 246: 66-72.

Wadleigh, L., and M. J. Jenkins. 1996. Fire frequency and the vegetative mosaic of a spruce-fir forest in northern Utah. Great Basin Naturalist 56(1): 28-37.

Wagstaff, F. J. 1984. Economic considerations in use and management of Gambel oak for fuelwood. USDA Forest Service General Technical Report INT-165. Intermountain Range Experiment Station, Ogden, UT.

Wallace, J. M., L. M. Wilson, and K. L. Launchbaugh. 2008. The effect of targeted grazing and biological control on yellow starthistle (*Centaurea solstitialis*) in canyon grasslands of Idaho. Rangeland Ecology and Management 61: 314-320.

Warner, T. J. 1989. The Spanish Epoch. In: R. D. Poll, T. G. Alexander, E. E. Campbell, and D. E. Miller (Eds.). Utah's History (pp. 35-51). Utah State University Press, Logan, UT.

Weber, K. T., B. McMahan, and G. Russell. 2001. Effect of livestock grazing and fire history on fuel load in sagebrush-steppe rangelands. In: K. T. Weber (Ed.). NASA Final Report: Wildfire Effects on Rangeland Ecosystems and Livestock grazing in Idaho (pp. 62-69). Idaho State University – GIS Training and Research Center. <http://giscenter.isu.edu/research/techpg/nasawildfire/ Final_Report/Documents/Chapter9.pdf>.

West, N. E. 1983a. Western Intermountain sagebrush steppe. In: N. E. West (Ed.). Ecosystems of the World Volume 5: Temperate Deserts and Semideserts (pp. 351-374). Elsevier Science Publication Company, Amsterdam, Netherlands.

West, N. E. 1983b. Great Basin-Colorado Plateau sagebrush semi-desert. In: N. E. West (Ed.). Ecosystems of the World Volume 5: Temperate Deserts and Semideserts (pp. 331-349). Elsevier Science Publication Company, Amsterdam, Netherlands.

West, N. E. 1983c. Intermountain salt-desert shrubland. In: N. E. West (Ed.). Ecosystems of the World Volume 5: Temperate Deserts and Semideserts (pp. 375-397). Elsevier Science Publication Company, Amsterdam, Netherlands.

West, N. E. 1983d. Colorado Plateau-Mohavian blackbrush semidesert. In: N. E. West (Ed.). Ecosystems of the World Volume 5: Temperate Deserts and Semideserts (pp. 399-411). Elsevier Science Publication Company, Amsterdam, Netherlands.

West, N. E. 1984a. Successional patterns and productivity potentials of pinyon-juniper ecosystems. In: National Research Council/National Academy of Sciences. Developing strategies for rangeland management (pp. 1301-1332). Westview Press, Boulder, CO.

West, N. E. 1984b. Factors affecting treatment success in the pinyon-juniper type. In: K. L. Johnson (Ed.). Proceedings of the Second Utah Shrub Ecology Workshop (pp. 21-33). Utah State University. Logan, UT.

West, N. E. 1999. Juniper-pinon savannas and woodlands of western North America. In: R. C. Anderson, J.S. Fralish, and J. M. Baskin (Eds.). Savannas, Barrens, and Rock Outcrop Plant Communities of North America (pp.. 288-308). Cambridge University Press, New York, NY.

West, N. E., F. D. Provenza, P. S. Johnson, and M. K. Owens. 1984. Vegetation change after 13 years of livestock grazing exclusion on sagebrush semidesert in west central Utah. Journal of Range Management 37: 262-264.

West, N. E., and M. S. Hassan. 1985. Recovery of sagebrush-grass vegetation following wildfire. Journal of Range Management 38: 131-134.

West, N. E., and N. S. Van Pelt. 1987. Successional patterns in pinyon-juniper woodlands. In: R. L. Everett (Comp.). Proceedings of Pinyon-Juniper Conference. USDA Forest Service General Technical Report INT-215 (pp. 43-52). Intermountain Research Station, Ogden, UT.

West, N. E., R. J. Tausch, and A. A. Nabi. 1979. Patterns and rates of pinyon-juniper invasion and degree of suppression of understory vegetation in the Great Basin. Range Improvement Notes. USDA Forest Service. Intermountain Region, Ogden, UT.

West, N. E., R. J. Tausch, and P. T. Tueller. 1998. A management-oriented classification of pinyon-juniper woodlands of the Great Basin. USDA Forest Service General Technical Report RMRS-GTR-12. Rocky Mountain Research Station. Ogden, UT.

Williams, D. C. 2000. Urban Sprawl. ABC-CLIO, Inc., Santa Barbara, CA.

Workman, J. P., and S. G. Evans. 1993. Utah ranches: an economic snapshot. Rangelands 15(6): 253-255.

Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use office in sagebrush-grass and pinyon-juniper plant communities: a state-of-the-art review. USDA Forest Service General Technical Report INT-58. Intermountain Forest and Range Experiment Station, Ogden, UT.

Wuerthner, G. 2006. The Wildfire Reader: A Century of Failed Forest Policy. Island Press, Sausalito, CA.

Yoder, J., M. Tilley, D. Engle, and S. Fuhlendorf. 2003. Economics and prescribed fire law in the United States. Review of Agricultural Economics 25(1): 218-233.

Zimmerman, G. T., and L. F. Neuenschwander. 1984. Livestock grazing influences on community structure, fire intensity, and fire frequency within the douglas-fir/ninebark habitat type. Journal of Range Management 37(2): 104-110.

APPENDIX A - LAND OWNERSHIP OF UTAH TABLES

Table 1. Utah counties ranked by size.

COUNTY RANK	COUNTY	AREA (ACRES)	AREA (SQUARE MILES)
1	SAN JUAN COUNTY	5,075,066	7,930
2	TOOELE COUNTY	4,663,000	7,286
3	MILLARD COUNTY	4,375,799	6,837
4	BOX ELDER COUNTY	4,306,769	6,729
5	GARFIELD COUNTY	3,331,074	5,205
6	UINTAH COUNTY	2,882,433	4,504
7	EMERY COUNTY	2,859,982	4,469
8	KANE COUNTY	2,627,474	4,105
9	GRAND COUNTY	2,356,835	3,683
10	JUAB COUNTY	2,179,759	3,406
11	IRON COUNTY	2,113,375	3,302
12	DUCHESNE COUNTY	2,077,014	3,245
13	BEAVER COUNTY	1,654,466	2,585
14	WAYNE COUNTY	1,577,474	2,465
15	WASHINGTON COUNTY	1,556,231	2,432
16	UTAH COUNTY	1,370,107	2,141
17	SEVIER COUNTY	1,227,086	1,917
18	SUMMIT COUNTY	1,202,657	1,879
19	SANPETE COUNTY	1,024,901	1,601
20	CARBON COUNTY	949,848	1,484
21	WASATCH COUNTY	773,294	1,208
22	CACHE COUNTY	750,161	1,172
23	RICH COUNTY	694,756	1,086
24	SALT LAKE COUNTY	515,360	805
25	PIUTE COUNTY	489,675	765
26	DAGGETT COUNTY	462,201	722
27	WEBER COUNTY	421,973	659
28	DAVIS COUNTY	406,321	635
29	MORGAN COUNTY	390,679	610
	STATE OF UTAH	54,315,768	84,868

Source: State of Utah Automated Geographic Reference Center (area calculations generated in ArcGIS 9.3 using Hawth's Analysis Tools).

Table 2. Land ownership by county (reported in acres).

COUNTY	BUREAU OF LAND MANAGEMENT	BLM WILDERNESS	U.S. FOREST SERVICE	USFS WILDERNESS	NATIONAL PARK SERVICE
BEAVER COUNTY	1,138,604	0	138,960	0	0
BOX ELDER COUNTY	1,078,816	0	90,356	11,900	2,215
CACHE COUNTY	131	0	230,948	54,830	0
CARBON COUNTY	421,042	0	30,264	0	0
DAGGETT COUNTY	114,180	0	257,783	0	0
DAVIS COUNTY	287	0	38,852	0	0
DUCHESNE COUNTY	207,817	0	431,641	290,578	0
EMERY COUNTY	2,061,995	0	211,980	0	2,098
GARFIELD COUNTY	1,490,972	0	1,021,059	25,248	461,626
GRAND COUNTY	1,544,237	5,069	56,695	0	76,470
IRON COUNTY	963,906	0	236,123	7,069	8,846
JUAB COUNTY	1,439,563	0	98,421	18,891	0
KANE COUNTY	1,633,238	21,292	123,483	0	469,027
MILLARD COUNTY	3,010,180	0	367,933	0	0
MORGAN COUNTY	733	0	16,534	0	0
PIUTE COUNTY	166,074	0	196,357	0	0
RICH COUNTY	171,513	0	52,219	0	0
SALT LAKE COUNTY	1,970	0	60,798	36,915	0
SAN JUAN COUNTY	2,076,843	0	403,863	46,021	588,838
SANPETE COUNTY	135,356	0	391,639	0	0
SEVIER COUNTY	205,175	0	732,548	0	4,468
SUMMIT COUNTY	722	0	359,195	161,890	0
TOOELE COUNTY	1,804,872	99,428	136,109	25,156	0
UINTAH COUNTY	1,367,917	0	269,682	0	51,886
UTAH COUNTY	104,424	0	446,987	38,572	254
WASATCH COUNTY	2,016	0	431,953	0	0
WASHINGTON COUNTY	632,470	3,667	344,930	50,237	131,892
WAYNE COUNTY	892,550	0	160,080	0	297,760
WEBER COUNTY	41	0	55,118	0	0
STATE OF UTAH	22,667,643	129,456	7,392,510	767,308	2,095,382

Source: State of Utah Automated Geographic Reference Center (area calculations generated in ArcGIS 9.3 using Hawth's Analysis Tools).
Note: Area calculations may not sum to the total of county area in Table 1, because calculations are based on two different datasets.

Table 2 (continued). Land ownership by county (reported in acres).

COUNTY	DEPARTMENT OF DEFENSE	U.S. FISH & WILDLIFE SERVICE	STATE TRUST LANDS	STATE SOVEREIGN LAND	STATE WILDLIFE RESERVES
BEAVER COUNTY	0	0	155,117	0	11,925
BOX ELDER COUNTY	205,548	55,178	178,030	719,539	43,090
CACHE COUNTY	0	0	16,996	0	20,768
CARBON COUNTY	0	0	108,184	0	16,503
DAGGETT COUNTY	0	0	29,530	0	11,075
DAVIS COUNTY	5,825	0	19	237,192	2,000
DUCHESNE COUNTY	0	0	54,359	0	90,622
EMERY COUNTY	9	0	335,161	2,958	9,549
GARFIELD COUNTY	0	0	157,394	1,431	1,589
GRAND COUNTY	2,527	0	344,657	14,543	8,538
IRON COUNTY	0	0	131,638	0	8,130
JUAB COUNTY	207	17,975	168,423	0	14,379
KANE COUNTY	0	0	99,821	3,822	264
MILLARD COUNTY	0	0	377,948	0	27,144
MORGAN COUNTY	0	0	80	0	7,516
PIUTE COUNTY	0	0	57,037	0	4,898
RICH COUNTY	0	0	47,383	35,675	2,437
SALT LAKE COUNTY	0	0	294	26,890	3,244
SAN JUAN COUNTY	0	0	260,598	6,278	0
SANPETE COUNTY	0	0	31,817	0	28,880
SEVIER COUNTY	0	0	42,291	0	3,701
SUMMIT COUNTY	0	0	8,621	0	17,623
TOOELE COUNTY	1,576,379	0	257,096	240,508	1,670
UINTAH COUNTY	0	7,681	238,733	9,307	23,511
UTAH COUNTY	15,627	0	46,453	95,216	43,193
WASATCH COUNTY	0	0	17,015	0	38,619
WASHINGTON COUNTY	0	0	77,489	0	848
WAYNE COUNTY	0	0	168,921	8	778
WEBER COUNTY	408	0	738	60,711	29,386
STATE OF UTAH	1,806,529	80,834	3,411,845	1,454,078	471,879

Table 2 (continued). Land ownership by county (reported in acres).

COUNTY	STATE PARKS	OTHER STATE	PRIVATE	TRIBAL
BEAVER COUNTY	212	0	209,624	0
BOX ELDER COUNTY	12,152	11	1,909,546	0
CACHE COUNTY	682	0	425,653	0
CARBON COUNTY	3,831	0	369,898	125
DAGGETT COUNTY	0	0	49,609	0
DAVIS COUNTY	24,544	0	97,601	0
DUCHESNE COUNTY	7,404	0	601,723	392,871
EMERY COUNTY	3,529	326	232,337	38
GARFIELD COUNTY	1,345	105	170,306	0
GRAND COUNTY	3,413	11	102,508	198,109
IRON COUNTY	294	0	754,780	2,503
JUAB COUNTY	81	22	376,951	44,835
KANE COUNTY	5,969	0	270,503	0
MILLARD COUNTY	14	0	591,323	1,186
MORGAN COUNTY	2,477	0	363,338	0
PIUTE COUNTY	120	0	65,189	0
RICH COUNTY	964	0	384,458	0
SALT LAKE COUNTY	573	32	377,459	7,184
SAN JUAN COUNTY	1,074	0	411,918	1,279,323
SANPETE COUNTY	240	0	436,212	756
SEVIER COUNTY	1,143	133	236,330	1,297
SUMMIT COUNTY	1,860	0	652,679	0
TOOELE COUNTY	1,008	0	501,341	19,374
UINTAH COUNTY	4,235	0	435,627	473,796
UTAH COUNTY	134	0	579,248	0
WASATCH COUNTY	31,251	0	249,276	3,164
WASHINGTON COUNTY	10,166	201	275,941	28,190
WAYNE COUNTY	0	0	57,377	0
WEBER COUNTY	590	0	274,981	0
STATE OF UTAH	119,304	841	11,463,739	2,452,750

Table 3. Major land ownership categories by county (reported in acres and percent of total county area).

COUNTY	FEDERAL		STATE		PRIVATE		TRIBAL	
	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT	ACRES	PERCENT
BEAVER COUNTY	1,277,563	77.2	167,254	10.1	209,624	12.7	0	0.0
BOX ELDER COUNTY	1,444,013	33.5	952,822	22.1	1,909,546	44.3	0	0.0
CACHE COUNTY	285,909	38.1	38,446	5.1	425,653	56.8	0	0.0
CARBON COUNTY	451,306	47.5	128,519	13.5	369,898	38.9	125	0.0
DAGGETT COUNTY	371,963	80.5	40,605	8.8	49,609	10.7	0	0.0
DAVIS COUNTY	44,964	11.1	263,756	64.9	97,601	24.0	0	0.0
DUCHESNE COUNTY	930,036	44.8	152,385	7.3	601,723	29.0	392,871	18.9
EMERY COUNTY	2,276,083	79.6	351,524	12.3	232,337	8.1	38	0.0
GARFIELD COUNTY	2,998,904	90.0	161,864	4.9	170,306	5.1	0	0.0
GRAND COUNTY	1,684,997	71.5	371,162	15.7	102,508	4.3	198,109	8.4
IRON COUNTY	1,215,943	57.5	140,062	6.6	754,780	35.7	2,503	0.1
JUAB COUNTY	1,575,058	72.3	182,905	8.4	376,951	17.3	44,835	2.1
KANE COUNTY	2,247,041	85.5	109,876	4.2	270,503	10.3	0	0.0
MILLARD COUNTY	3,378,114	77.2	405,106	9.3	591,323	13.5	1,186	0.0
MORGAN COUNTY	17,267	4.4	10,073	2.6	363,338	93.0	0	0.0
PIUTE COUNTY	362,431	74.0	62,054	12.7	65,189	13.3	0	0.0
RICH COUNTY	223,733	32.2	86,459	12.4	384,458	55.3	0	0.0
SALT LAKE COUNTY	99,683	19.3	31,033	6.0	377,459	73.2	7,184	1.4
SAN JUAN COUNTY	3,115,565	61.4	267,950	5.3	411,918	8.1	1,279,323	25.2
SANPETE COUNTY	526,995	51.4	60,937	5.9	436,212	42.6	756	0.1
SEVIER COUNTY	942,191	76.8	47,268	3.9	236,330	19.3	1,297	0.1
SUMMIT COUNTY	521,807	43.4	28,104	2.3	652,679	54.3	0	0.0
TOOELE COUNTY	3,641,945	78.1	500,281	10.7	501,341	10.8	19,374	0.4
UINTAH COUNTY	1,697,166	58.9	275,786	9.6	435,627	15.1	473,796	16.4
UTAH COUNTY	605,863	44.2	184,996	13.5	579,248	42.3	0	0.0
WASATCH COUNTY	433,968	56.1	86,885	11.2	249,276	32.2	3,164	0.4
WASHINGTON COUNTY	1,163,197	74.8	88,703	5.7	275,941	17.7	28,190	1.8
WAYNE COUNTY	1,350,390	85.6	169,706	10.8	57,377	3.6	0	0.0
WEBER COUNTY	55,567	13.2	91,425	21.7	274,981	65.2	0	0.0
STATE OF UTAH	34,939,663	64.3	5,457,946	10.0	11,463,739	21.1	2,452,750	4.5

Source: State of Utah Automated Geographic Reference Center (area calculations generated in ArcGIS 9.3 using Hawth's Analysis Tools).
Note: Area calculations may not sum to the county areas reported in Table 1, because calculations are based on two different datasets.

Table 4. Bureau of Land Management districts and resource management areas/field offices.

BLM DISTRICT	FIELD OFFICE/ RESOURCE MANAGEMENT AREA	TOTAL AREA (ACRES)	BLM LAND WITHIN MANAGEMENT AREA (ACRES)	PERCENT BLM LAND
CANYON COUNTRY DISTRICT	MOAB	2,856,078	1,844,712	64.6
	MONTICELLO	4,582,951	1,784,813	38.9
COLOR COUNTRY DISTRICT	CEDAR CITY	3,754,797	2,104,218	56.0
	KANAB	2,912,228	555,268	19.1
	RICHFIELD	5,480,117	2,127,106	38.8
	ST. GEORGE	1,574,146	630,600	40.1
GREEN RIVER DISTRICT	PRICE	3,802,983	2,480,563	65.2
	VERNAL	5,421,367	1,689,914	31.2
WEST DESERT DISTRICT	FILLMORE	6,555,558	4,449,743	67.9
	SALT LAKE	15,495,075	3,266,722	21.1
GSENM	GSENM	1,880,467	1,866,001	99.2

Table 5. Areas of Critical Environmental Concern by county.

COUNTY	ACEC
BOX ELDER	Blue Springs Wildlife Habitat Area
	Central Pacific Railroad Grade
	Donner Creek/Bettridge Creek
	Salt Wells Wildlife Habitat Area
CACHE	Laketown Canyon (Rich County)
DAGGETT	Browns Park (Uintah County)
	Red Creek Watershed
DUCHESNE	Lears Canyon
	Pariette Wetlands (Uintah County)
EMERY	Big Flat Tops
	Bow Knot Bend
	Copper Globe
	Dry Lake Archaeological District
	I-70 Scenic Corridor
	Lower San Rafael Canyon
	Middle San Rafael Canyon
	Muddy Creek
	Muddy Creek Tomsich Butte
	Pictographs
	San Rafael Reef North
	San Rafael Reef South
	Segers Hole
	Sids Mountain
	Swasey Cabin
	Temple Mountain Historic District
	Upper San Rafael Canyon

COUNTY	ACEC
GRAND	Negro Bill Canyon
JUAB	Rockwell Natural Area
KANE	Water/South Fork Indian Canyon
MILLARD	Fossil Mountain
	Gandy Mountain Caves
	Gandy Salt Marsh
	Pavant Butte
	Tabernacle Hill Lava Field
	Wah Wah Mountains
RICH	Laketown Canyon (Cache County)
SAN JUAN	Alkali Ridge
	Bridger Jack Mesa
	Butler Wash
	Cedar Mesa
	Dark Canyon
	Hovenweep
	Indian Creek
	Lavender Mesa
	Scenic Highway Corridor
	Shay Canyon
TOOELE	Bonneville Salt Flats
	Horseshoe Springs

Source: Bureau of Land Management.
Note: Some ACECs occur in more than one county.

Table 5 (continued). Areas of Critical Environmental Concern by county.

COUNTY	ACEC
UINTAH	Browns Park (Daggett County)
	Lower Green River
	Ninemile Canyon (Duchesne County)
	Ninemile Canyon (Uintah County)
	Pariette Wetlands (Duchesne County)
	Red Mountain-Dry Fork Complex
WASHINGTON	Beaver Dam Slope
	Canaan Mountain
	Little Creek Mountain
	Lower Virgin River
	Red Bluff
	Red Mountain
	Santa Clara Gunlock
	Santa Clara Land Hill
	Upper Beaver Dam Wash
	Warner Ridge/Fort Pearce
WAYNE	Beaver Wash Canyon
	Gilbert Badlands
	North Caineville Mesa
	South Caineville Mesa

Table 6. Outstanding Natural Areas by county.

COUNTY	OUTSTANDING NATURAL AREA
GARFIELD	Calf Creek Recreation Site
	Deer Creek Recreation Site
	Devils Garden Outstanding Natural Area
	Escalante Canyons Outstanding Natural Area
	North Escalante Canyon Outstanding Natural Area
	Phipps-Death Hollow Outstanding Natural Area
	The Gulch Outstanding Natural Area
	Wolverine Petrified Wood Natural Area
KANE	Dance Hall Rock Historic Site
	No Mans Mesa Research Natural Area

Source: Bureau of Land Management.

Table 7. Wilderness Study Areas by county.

COUNTY	WILDERNESS STUDY AREA
BEAVER	White Rock Range
	Wah Wah Mountains (Millard County)
CARBON	Jack Canyon
	Desolation Canyon (Emery & Grand Counties)
DAGGETT	Diamond Breaks
	West Cold Springs
EMERY	Desolation Canyon (Carbon & Grand Counties)
	Crack Canyon
	Devils Canyon
	Link Flats Instant Study Area
	Mexican Mountain
	Muddy Creek
	San Rafael Reef
	Sids Cabin 202
	Sids Mountain
	Turtle Canyon
	North Horseshoe Canyon (Wayne County)
GARFIELD	Devils Garden Instant Study Area
	Escalante Canyons Tract 1
	Fiddler Butte
	Little Rockies
	Mt. Hillers
	Mt. Pennel
	North Escalante Canyons/The Gulch
	Phipps-Death Hollow Instant Study Area
	Steep Creek
	The Blues
	Carcass Canyon (Kane County)
	Mud Spring Canyon (Garfield County)
	Bull Mountain (Wayne County)
	Death Ridge (Kane County)
	Scorpion (see Kane County)
	French Spring-Happy Canyon (Wayne County)
	Mt. Ellen-Blue Hills (Wayne County)
GRAND	Desolation Canyon (Carbon & Emery Counties)
	Black Ridge Canyon West
	Coal Canyon
	Floy Canyon
	Flume Canyon
	Lost Spring Canyon
	Mill Creek Canyon

Source: Bureau of Land Management.
Note: Some WSAs occur in more than one county.

Table 7 (continued). Wilderness Study Areas by county.

COUNTY	WILDERNESS STUDY AREA
GRAND	Negro Bill Canyon
	Spruce Canyon
	Westwater Canyon
	Behind the Rocks (San Juan County)
IRON	Spring Creek Canyon
JUAB	Fish Springs
	Rockwell
	Scott's Basin
	Deep Creek Mountains (Tooele County)
KANE	Burning Hills
	Canaan Mountain (Washington County)
	Carcass Canyon (Grand County)
	Death Ridge (Garfield County)
	Escalante Canyons Tract 5 Instant Study Area
	Fiftymile Mountain
	Moquith Mountain
	Mud Spring Canyon (Kane County)
	North Fork Virgin River
	Orderville Canyon
	Paria-Hackberry
	Paria-Hackberry 202
	Parunuweap Canyon
	Scorpion (Garfield County)
	The Cockscomb
	Wahweap
MILLARD	Conger Mountain
	Howell Peak
	King Top
	Notch Peak
	Swasey Mountain
	Wah Wah Mountains (Beaver County)
SAN JUAN	Behind the Rocks (Grand County)
	Bridger Jack Mesa
	Butler Wash
	Cheese Box Canyon
	Cross Canyon
	Dark Canyon Instant Study Area Complex
	Fish Creek Canyon
	Grand Gulch Instant Study Area Complex
	Indian Creek
	Mancos Mesa
	Mule Canyon
	Road Canyon

COUNTY	WILDERNESS STUDY AREA
SAN JUAN	South Needles
	Squaw/Papoose Canyon
TOOELE	Deep Creek Mountains (Juab County)
	North Stansbury Mountains
UINTAH	Book Cliffs Mountain Browse Instant Study Area
	Bull Canyon
	Daniels Canyon
	Winter Ridge
WASHINGTON	Beartrap Canyon
	Canaan Mountain (Kane County)
	Cottonwood Canyon
	Cougar Canyon
	Deep Creek
	Goose Creek Canyon
	Joshua Tree Instant Study Area
	LaVerkin Creek Canyon
	Red Butte
	Red Mountain
	Red Mountain 202
	Taylor Creek Canyon
	The Watchman
WAYNE	Bull Mountain (Garfield County)
	Dirty Devil
	Fremont Gorge
	French Spring-Happy Canyon (Garfield County)
	Mt. Ellen-Blue Hills (Garfield County)
	North Horseshoe Canyon (Emery County)
	South Horseshoe Canyon

Table 8. Ranger districts by national forest in Utah (legend corresponds to Figure 2.4).

NATIONAL FOREST	LEGEND	RANGER DISTRICT
ASHLEY NATIONAL FOREST	A1	DUCHESNE
	A2	FLAMING GORGE
	A3	ROOSEVELT
	A4	VERNAL
CARIBOU NATIONAL FOREST	C1	WESTSIDE
DIXIE NATIONAL FOREST	D1	CEDAR CITY
	D2	ESCALANTE
	D3	PINE VALLEY
	D4	POWELL
FISHLAKE NATIONAL FOREST	F1	BEAVER
	F2	FILLMORE
	F3	FREMONT
	F4	RICHFIELD
	F5	TEASDALE
MANTI-LA SAL NATIONAL FOREST	M1	FERRON
	M2	MOAB
	M3	MONTICELLO
	M4	PRICE
	M5	SANPETE
SAWTOOTH NATIONAL FOREST	S1	MINIDOKA
UINTA-WASATCH-CACHE NATIONAL FOREST	U1	EVANSTON
	U2	HEBER
	U3	KAMAS
	U4	LOGAN
	U5	MOUNTAIN VIEW
	U6	OGDEN
	U7	PLEASANT GROVE
	U8	SALT LAKE
	U9	SPANISH FORK

Source: United States Forest Service (USFS).

APPENDIX B - PHYSIOGRAPHY OF UTAH TABLE

Table 1. Descriptions of Level III Omernik (EPA) Ecoregions occurring in Utah.
For more information: http://www.epa.gov/wed/pages/ecoregions/ut_eco.htm.

LEVEL III ECOREGION	ENVIRONMENTAL PROTECTION AGENCY (EPA) DESCRIPTION
CENTRAL BASIN AND RANGE	The Central Basin and Range Ecoregion is characterized by a mosaic of xeric basins, scattered low and high mountains, and salt flats. Compared to the Snake River Basin and Northern Basin and Range regions to the north, the region is hotter and contains higher and a greater density of mountains that have perennial streams and ponderosa pine forests at higher elevations. Also, there is less grassland and more shrubland, and the soils are mostly Aridisols rather than dry Mollisols. The region is not as hot as the Mojave and Sonoran Basin and Range ecoregions and it has a greater percent of land that is grazed.
COLORADO PLATEAUS	Rugged tableland topography is typical of the Colorado Plateau ecoregion. Precipitous side-walls mark abrupt changes in local relief, often from 300 to 600 meters. The region is more elevated than the Wyoming Basin to the north and therefore contains a far greater extent of pinyon-juniper woodlands. However, the region also has large low lying areas containing saltbrush-greasewood (typical of hotter drier areas), which are generally not found in the higher Arizona/New Mexico Plateau to the south where grasslands are common.
MOJAVE BASIN AND RANGE	This ecoregion contains scattered mountains which are generally lower than those of the Central Basin and Range. Potential natural vegetation in this region is predominantly creosote bush, as compared to the mostly saltbush-greasewood and Great Basin sagebrush of the ecoregion to the north, and creosote bush-bur sage with large patches of palo verde-cactus shrub and saguaro cactus in the Sonoran Basin and Range to the south. Most of this region is federally owned and there is relatively little grazing activity because of the lack of water and forage for livestock. Heavy use of off-road vehicles and motorcycles in some areas has caused severe wind and water erosion problems.
NORTHERN BASIN AND RANGE	This ecoregion consists of arid tablelands, intermontane basins, dissected lava plains, and widely scattered low mountains. The bulk of the region is covered by sagebrush steppe vegetation. The ecoregion is drier and less suitable for agriculture than the Columbia Plateau, it is higher and cooler than the Snake River Basin to the east, and contains a lower density of mountain ranges than the adjacent Central Basin and Range ecoregion to the south. Much of the region is used as rangeland.
SOUTHERN ROCKIES	The Southern Rockies are composed of high elevation, steep rugged mountains. Although coniferous forests cover much of the region, as in most of the mountainous regions in the western United States, vegetation, as well as soil and land use, follows a pattern of elevational banding. The lowest elevations are generally grass or shrub covered and heavily grazed. Low to middle elevations are also grazed and covered by a variety of vegetation types including Douglas fir, ponderosa pine, aspen, and juniper oak woodlands. Middle to high elevations are largely covered by coniferous forests and have little grazing activity. The highest elevations have alpine characteristics.
WASATCH AND UINTA MOUNTAINS	This ecoregion is composed of a core area of high, precipitous mountains with narrow crests and valleys flanked in some areas by dissected plateaus and open high mountains. The elevational banding pattern of vegetation is similar to that of the Southern Rockies except that aspen, chaparral, and juniper-pinyon and oak are more common at middle elevations. This characteristic, along with a far lesser extent of lodgepole pine and greater use of the region for grazing livestock in the summer months, distinguish the Wasatch and Uinta Mountains ecoregion from the more northerly Middle Rockies.
WYOMING BASIN	This ecoregion is a broad intermontane basin dominated by arid grasslands and shrublands and interrupted by high hills and low mountains. Nearly surrounded by forest covered mountains, the region is somewhat drier than the Northwestern Great Plains to the northeast and does not have the extensive cover of pinyon-juniper woodland found in the Colorado Plateaus to the south. Much of the region is used for livestock grazing, although many areas lack sufficient vegetation to support this activity. The region contains major producing natural gas and petroleum fields.

APPENDIX C - LIVESTOCK GRAZING IN UTAH TABLES

Table 1. AUMs of livestock grazing licensed by the BLM in the state of Utah (1940-2008).

YEAR	CATTLE AND HORSE AUMs LICENSED BY THE BLM	SHEEP AND GOAT AUMs LICENSED BY THE BLM	TOTAL AUMs LICENSED BY THE BLM
1940	891,000	1,858,000	2,749,000
1945	945,000	1,562,000	2,507,000
1950	1,085,000	1,276,000	2,361,000
1955	1,047,000	1,055,000	2,102,000
1960	811,000	949,000	1,760,000
1965	706,821	699,955	1,406,776
1970	684,540	587,992	1,272,532
1975	677,661	418,681	1,096,342
1980	564,025	249,575	813,600
1985	691,049	284,998	976,047
1990	482,754	218,658	701,412
1995	666,555	201,608	868,163
2000	674,394	159,321	833,715
2005	503,701	118,785	622,486
2008	548,926	126,596	675,522

Sources: Bureau of Land Management (BLM) Rangeland Administration System (RAS), Public Land Statistics (1996-2008), BLM Facts and Figures (1981-1994).

Table 2. AUMs of livestock grazing permitted by the BLM in the state of Utah (1996-2008).

YEAR	ACTIVE PREFERENCE AUMs	SUSPENDED AUMs	LICENSED AUMS
1996	1,285,528	319,773	798,881
1997	1,278,515	352,897	798,881
1998	1,272,628	352,952	890,741
1999	1,261,822	347,263	880,091
2000	1,246,639	340,715	833,715
2001	1,234,136	347,876	678,393
2002	1,236,840	333,749	703,067
2003	1,230,244	332,308	439,185
2004	1,222,517	333,659	544,458
2005	1,238,877	327,782	622,486
2006	1,239,786	324,140	686,627
2007	1,225,890	323,783	711,160
2008	1,209,929	319,110	675,522

Sources: Bureau of Land Management (BLM) Rangeland Administration System (RAS), Public Land Statistics (1996-2008).

Table 3. AUMs of livestock grazing authorized by the USFS in the state of Utah (1988-2008).

YEAR	CATTLE AUMs	HORSE AUMs	SHEEP AUMs	TOTAL AUMS
1988	472,521	3,607	200,793	674,819
1992	401,939	5,167	172,693	579,799
1994	424,345	2,201	126,300	552,846
1995	424,202	2,076	126,300	552,578
1996	393,180	1,999	98,199	493,378
1997	419,198	1,899	102,652	523,748
1998	419,198	1,819	102,652	523,668
2000	447,660	753	101,618	550,031
2001	431,590	951	103,353	535,895
2002	389,866	1,149	99,501	490,516
2003	268,643	750	55,910	325,303
2004	364,506	1,179	82,876	448,561
2005	395,619	1,215	84,292	481,126
2006	396,015	868	102,377	499,260
2007	396,952	7,387	123,633	527,972
2008	475,591	1,152	137,524	614,267

Sources: Report of the Forest Service (1988-2008), Grazing Statistical Summary Reports (2000-2008).

APPENDIX D - RECREATION IN UTAH TABLES

Table 1. Other recreational destinations in Utah.

OTHER UTAH RECREATIONAL DESTINATIONS
Bonneville Salt Flats
Boulder Mountain
Canyon Rims Recreation Area
Canyons of the Escalante
Cleveland Lloyd Dinosaur Quarry
Four Corners
Grand Gulch Primitive Area
Great Salt Lake
Henry Mountains
Jarvie Property
Labyrinth Canyon/Green River
Mill Canyon/Copper Ridge
Monument Valley
Mule Canyon
Nine Mile Canyon/Rock Art
Paria Canyon/Paria River
Pariette Wetlands
Uinta Mountains
Parowan Gap
Pony Express Trail
San Rafael Swell
Sand Flats Moab Slickrock
Transcontinental Railroad
Westwater Canyon/Colorado River

Table 2. Utah river rafting destinations.

UTAH RIVER RAFTING DESTINATIONS
Cataract Canyon
Desolation Canyon
Dolores River
Fisher Towers
Green River
Labyrinth Canyon
Lodore Canyon
Provo River
San Juan River
Sevier River
Split Mountain
Stillwater Canyon
Virgin River
Weber River
Westwater Canyon
White River
Yampa River

Table 3. Utah ski resorts.

UTAH SKI RESORTS
Alta Ski Resort
Beaver Mountain
Brian Head Resort
Brighton Resort
Deer Valley Resort
Park City Mountain Resort
Powder Mountain Resort
Snowbasin Resort
Snowbird Resort
Solitude
Sundance Resort
The Canyons Resort
Wolf Mountain Resort

Table 4. National scenic byways in Utah.

NATIONAL SCENIC BYWAYS
Dinosaur Diamond Prehistoric Highway
Flaming Gorge - Uintas National Scenic Byway
Highway 12 Scenic Byway
Logan Canyon Scenic Byway
Nebo Loop Scenic Byway
The Energy Loop: Huntington/Eccles Canyon Scenic Byway
Trail of the Ancients

Table 5. State of Utah scenic byways.

UTAH SCENIC BYWAYS
Bear Lake Scenic Byway
Beaver Canyon Scenic Byway
Bicentennial Highway
Big Cottonwood Canyon Scenic Byway
Brian Head-Panguitch Lake
Capitol Reef Country Scenic Byway
Cedar Breaks Scenic Byway
Dead Horse Point Mesa Scenic Byway
Fishlake Scenic Byway
Indian Canyon Scenic Byway
Indian Creek Corridor Scenic Byway
Kolob Fingers Road Scenic Byway
Little Cottonwood Canyon Scenic Byway
Markaquant High Plateau Scenic Byway
Mirror Lake Scenic Byway
Monument Valley to Bluff Scenic Byway
Mt. Carmel Scenic Byway
Ogden River Scenic Byway
Potash-Lower Colorado River Scenic Byway
Provo Canyon Scenic Byway
Upper Colorado River Scenic Byway
Zion Park Scenic Byway